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Reviews

THE IMPACT OF CHEAP NITROGEN

C. M. DONALD

The most widespread nutrient deficiency in world agriculture is that of nitrogen and all but a few soils show a moderate to acute deficiency of this element. Nitrogen poses a rather different problem from most other nutrients because it is almost wholly contained in the soil organic matter, which in turn moves rapidly towards an equilibrium governed by the pattern of land use and crop production. Any deficiency of nitrogen which may exist at the equilibrium level is therefore less easily resolved on a long term or permanent basis than the deficiency of an element not so fully associated with the organic matter. The application of a few hundred pounds of phosphorus or a few ounces of molybdenum may remedy a deficiency for a long period, but this is not so with nitrogen, which will again move back to the equilibrium level within a relatively short time.

For this reason various agricultural practices, dating back for centuries and even millennia, have depended for their success either on promoting a satisfactory equilibrium level of organic matter and thus of nitrogen supply or on the provision of readily available nitrogen for immediate uptake by crops. The use of legumes, of fallowing, of farmyard manure, of green manure and of various rotation practices have all depended in more or less degree on their nitrogen contribution to man's crops. With the first understanding of the mineral nutrition of plants in the 1840's, fertilizer nitrogen came into being through the exploitation of Chilean nitrate, supplemented later in the century by sulphate of ammonia from gasworks. In the first decade of the twentieth century, the present phase began with the production of synthetic nitrogenous fertilizers from the nitrogen of the atmosphere, a production which has risen in exponential manner to the present day. Concurrently man has gained an understanding of older practices and in particular has advanced his techniques for the use of legumes in nitrogen fixation.

In the years since World War II there has been a marked decline in all countries in the real price of nitrogen to the farmer. These trends and their implications in world and Australian agriculture were reviewed by Russell in 1957 and the purpose of this article is to re-count further developments and to support the plea for more investigational work on nitrogen in Australia.

The Nitrogen of the Earth and of Agriculture

Though our knowledge of the distribution of the nitrogen of the earth is very incomplete, an attempt is made in Figure 1 to show the relationship of the nitrogen of the land surface, comprising the soils, plants and animals,

Professor C. M. Donald is Professor of Agriculture, University of Adelaide. *This article is based on an address to the Waite Agricultural Sciences Club, Adelaide, in April* 1960.

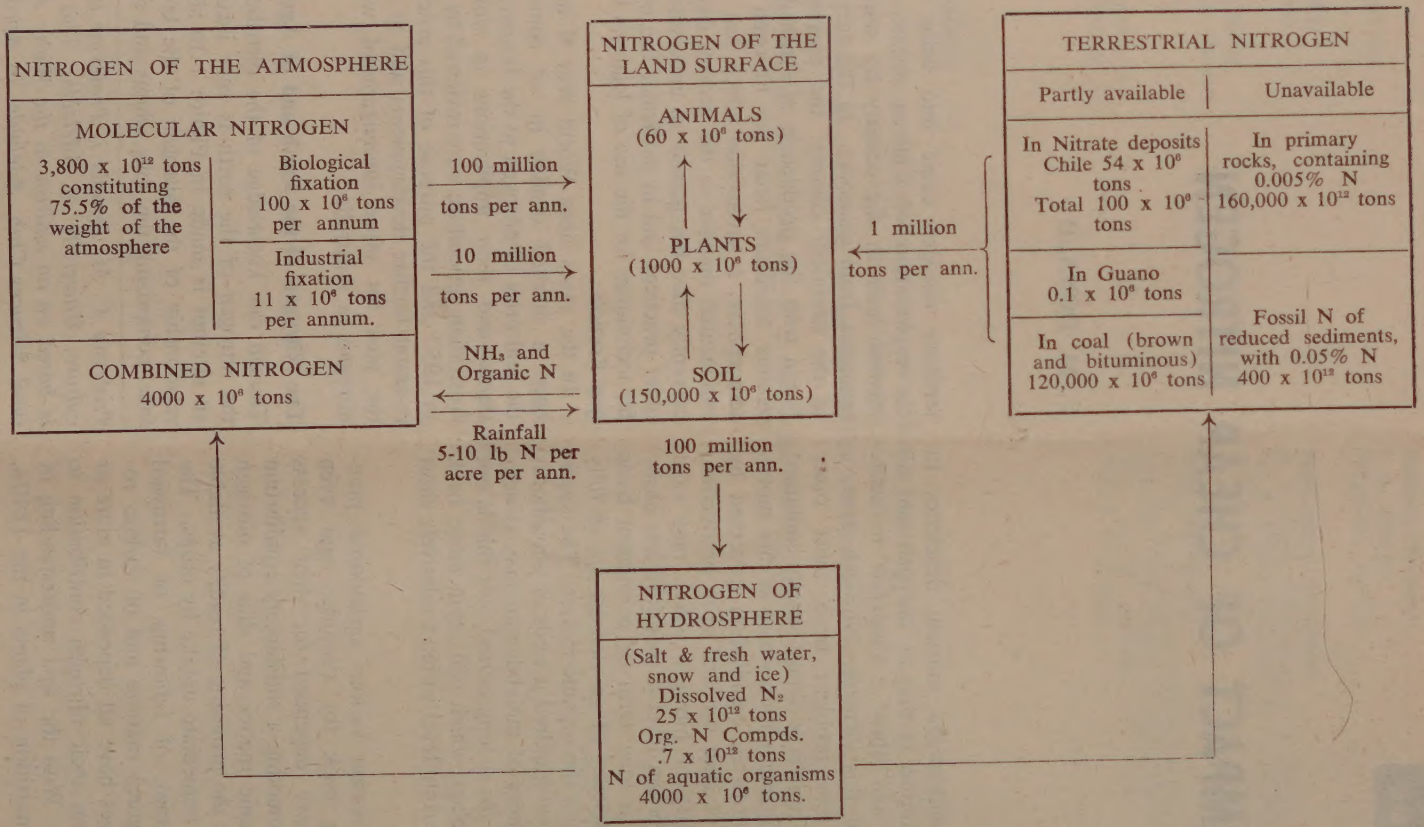

NITROGEN OF THE ATMOSPHERE
MOLECULAR NITROGEN
3,800 x 10¹² tons constituting 75.5% of the weight of the atmosphere
Biological fixation 100 x 10⁶ tons per annum
Industrial fixation 11 x 10⁶ tons per annum.
COMBINED NITROGEN
4000 x 10⁶ tons
100 million tons per ann.
10 million tons per ann.
NH₃ and Organic N
Rainfall 5-10 lb N per acre per ann.
NITROGEN OF THE LAND SURFACE
ANIMALS (60 x 10⁶ tons)
PLANTS (1000 x 10⁶ tons)
SOIL (150,000 x 10⁶ tons)
1 million tons per ann.
TERRESTRIAL NITROGEN
Partly available
Unavailable
In Nitrate deposits Chile 54 x 10⁶ tons Total 100 x 10⁶ tons
In primary rocks, containing 0.005% N 160,000 x 10¹² tons
In Guano 0.1 x 10⁶ tons
In coal (brown and bituminous) 120,000 x 10⁶ tons
Fossil N of reduced sediments, with 0.05% N 400 x 10¹² tons
100 million tons per ann.
NITROGEN OF HYDROSPHERE
(Salt & fresh water, snow and ice)
Dissolved N₂ 25 x 10¹² tons
Org. N Compds. .7 x 10¹² tons
N of aquatic organisms 4000 x 10⁶ tons.

Figure 1.—The Nitrogen of the Earth, and a partial account of its movement.

to that of the whole earth. Many of the data are drawn from Hutchinson (1954). Perhaps the most surprising feature is that the primary rocks, which contain only 0.005 per cent. N, bear most of the earth's nitrogen, but this, like the nitrogen of most of the sediments is commercially inaccessible. The only significant terrestrial deposits of nitrogen are those of Chilean nitrate, guano and coal. The nitrate deposits of Chile are estimated at 330 million tons, with 15 per cent. N, and these are currently being used at the rate of about 0.4 per cent. per annum. Guano, estimated to have been 0.1 million tons, is largely exhausted. The world's coal may approximate 8×10^{12} tons for both brown coal (0.5 per cent. N) and bituminous coal (1.8 per cent. N) with a mean nitrogen content of 1.5 per cent. These deposits are being mined at the rate of about 0.02 per cent. per annum, but only a part of this nitrogen reaches agriculture (perhaps comprising 5 per cent. of the nitrogenous fertilizers) with the balance passing in various forms to industry and to the atmosphere.

The total annual input to agriculture from these terrestrial sources is about 1 million tons of nitrogen, one fifth from Chilean nitrate and the balance from coal. If we turn to the nitrogen of the atmosphere, the deposits of nitrate, coal and guano seem utterly insignificant, since atmospheric N exceeds these deposits by several ten-thousand fold. Here then in the atmosphere is a great reserve of nitrogen, unlikely to be influenced in the slightest by man's use of nitrogen in agriculture. Two principal processes are available to tap this source—biological fixation and industrial fixation.

Attempts to assess the volume of nitrogen fixation by bacteria, blue-green algae and higher plants have been based on the estimates of the annual discharge of nitrogen into the oceans or on direct studies of nitrogen fixation in soils. Though the quantity cannot be stated precisely (Hutchinson gives an estimate of 12-105 million tons nitrogen per annum—the higher figure is here preferred) it is certain that biological fixation constitutes by far the main source of nitrogen for the soils and plants of the earth.

The industrial fixation of nitrogen has now (1958/59) attained some 11 million tons of which about 9.5 million tons are devoted to fertilizer production. Thus it is already of a comparable order to the estimates for total biological fixation and it is quite conceivable that it will become the greater source of nitrogen in decades to come. A source of soil nitrogen of uncertain significance is the nitrogen of the rainfall. Values from ½-60 lb per acre per annum have been recorded though some of the high values are of doubtful validity, and most estimates are about 5 to 10 lb per acre. But the main problem (Hutton, personal communication) is whether this constitutes a real input of nitrogen through the action of lightning in producing combined nitrogen in the atmosphere or whether it is a re-cycling of nitrogen which has been yielded to the atmosphere as plant dust, there to decompose and return to the earth as dissolved gases. In the latter case the nitrogen of the rainfall may serve only partially to re-distribute nitrogen from more fertile areas to less fertile zones nearby.

It is clear from all these considerations that the fixation of atmospheric nitrogen by biological or industrial means must provide the basis for the maintenance and more particularly for the increase of nitrogen supplies to agriculture. Of the biological processes, the fixation in the legume nodule is the one which has been most studied and exploited by man, and a point of contrast may be drawn between this process and the use of "synthetic" nitrogen. In the growth of nodulated legumes, nitrogen fixation and carbon fixation go hand in hand as closely integrated processes. When fertilizer nitrogen is used, the provision of the nitrogen to the crop precedes and is independent of the fixation of carbon. This has implications in terms of loss by leaching, of the need to use split doses, and of the varying effect of different forms of nitrogen. But subject to the fertilizer nitrogen being successfully combined with carbon the two processes should have similar implications in agriculture. There remains the economic difference between "free" legume nitrogen and that from the bag.

The World Production of Nitrogenous Fertilizers

The nitrogenous fertilizers of the world are now largely derived by the synthesis of atmospheric nitrogen into combined forms, as is shown by the composition of the world output of commercial nitrogen:

By ammonia synthesis	83.0%
As calcium cyanamide	7.5%
From by-product facilities (e.g., from "gasworks")	7.5%
As Chilean nitrate	2.0%

Ammonia, which may be used direct (anhydrous ammonia and aqua ammonia) or as ammonium nitrate, ammonium sulphate, or urea is synthesised industrially by the direct combination of nitrogen and hydrogen at high pressure (100-1000 atmospheres) and high temperature (500-700° C). Since nitrogen can be readily obtained by the fractional distillation of liquid air, the production of ammonia depends considerably on the availability of hydrogen at satisfactory cost. Before World War I, coal and coke-oven gas, mainly derived from steel works, was the source of 90 per cent of the hydrogen, but the current situation is very different. World ammonia synthesis now depends on hydrogen derived as follows:

Natural gas	31%
Gas from fuel oil	15%
Petroleum refinery gas	9%
Coal and coke oven gas	40%
Other (e.g. electrolysis of water)	5%

The first three of these sources of hydrogen are being steadily increased, especially in countries and districts in which coal is not readily available. Even the importation of fuel oil specifically for this purpose is proving a practical proposition in various countries without hydrogen resources.

The world output of nitrogenous fertilizers has risen in spectacular manner since the establishment of the atmospheric nitrogen industry in the first decade of the century, as is shown by the following figures.

Year	*Production of N Fertilizers 000 tons N*	*Notes on composition of production*
1900	340	About 2/3 Chilean nitrate and 1/3 gasworks N, with 1.4% synthetic N in 1910.
1918	1350	About 1/3 Chilean nitrate, 1/3 gasworks N and 1/3 synthetic N.
1938	2678	
1948	3559	About 8% Chilean nitrate, 15% by-product N and nearly 80% synthetic N.
1958/9	9416	2% Chilean nitrate, 7% by-product N and over 90% synthetic N.

The recent rate of increase in consumption has by no means been constant between countries as is shown in the following comparison.

Year	*1939*	*1949*	*1959*
	(thousand-tons N)		
U.K.	60	194	340
U.S.A.	385	920	2,643
Australia	13	—	31

Australia not only has a small consumption of nitrogen relative to the size of its agricultural industries but is increasing more slowly than many other countries in its use of this fertilizer.

Of the current output nearly 57 per cent. of production is in Europe and 26 per cent. in North America; Central and S. America produce 13 per cent., Asia 0.5 per cent. and Africa 2.8 per cent. The composition of production in each of these regions varies considerably but ammonium nitrate and ammonium sulphate are by far the most important in the world totals.

Production capacity has continued to rise very steeply in the past few years, with an increase of 8 per cent in production from 1957/58 to 1958/59. As a consequence output has tended to outstrip demand, not heavily, but at least enough to lead to intensive competition in a buyer's market. In the last 18 months the gap between productive capacity and demand has been maintained but the only

Fertilizer	Production 1958/59 (million tons N)	World total %
Ammonium nitrate	3.41	36.2
Ammonium sulphate	2.97	31.6
Urea	0.67	7.1
Anhydrous ammonia and aqua ammonia	0.63	6.7
Calcium nitrate	0.38	4.0
Calcium cyanamide	0.35	3.7
Sodium nitrate	0.20	2.1
Complex and other	0.81	8.6
	9.42	100.0
Total N production including industrial use	10.98	

serious surplus has been in Japan with its tremendous expansion of urea production. In the older producing countries there has been a slowing down of expansion but many of the importing areas have embarked on the erection of new plants. Indeed a glance at the list of countries which have recently erected nitrogen plants is impressive in its inclusion of so many small or non-industrialised countries — Algeria, Formosa, Malaya, Spain, Greece, Eire, Israel, Peru and so on. The country without a synthetic nitrogen industry is now becoming the exception.

A sparkling prospect for the further enhancement of nitrogen supplies lies in the recent announcement of nitrogen fixation at normal temperature and pressure, through the use of cell-free extracts of *Clostridium pasteurianum,* a free-living nitrogen-fixing soil organism (Carnahan *et al.* 1960). This process, achieved after drying, autolysis and centrifuging of cells under rigorous conditions, has been shown to proceed by the synthesis of ammonia. The research made possible by this step may well lead to altogether new processes for the production of cheap nitrogen.

The Production and Importation of Nitrogen Fertilizers in Australia

Australia uses both locally manufactured and imported nitrogenous fertilizers. In the post-war decade the production of sulphate of ammonia from the iron and steel industry, from ex-munitions works and from gasworks was much below needs. Fertilizer firms reviewed annually the level of imports needed to bridge the gap between prospective demand and supply, and this volume of imports of sulphate of ammonia and nitrate of soda was then sought under administrative licensing control. Imports of urea were also controlled and were limited to about 9,000 tons per annum.

In 1956 the structure of nitrogen fertilizer production in Australia was changed by the entry of the Electrolytic Zinc Company into the production of sulphate of ammonia, with a capacity of 55,000 tons per annum. Imports were not immediately adjusted and with the reduced demand following over-production in the sugar industry in 1958/59, local supplies exceeded demand. The last shipment of sulphate of ammonia entered Australia in December 1958 and subsequently there have even been small exports to such Asian countries as Ceylon, Vietnam and Red China. Meanwhile, since February 1960, nitrogenous fertilizers have not been subject to the import restrictions which had formed a part of the general economic policy.

The other principal development has been the growing importance of urea. Whereas, three years ago, European urea was imported at £80 per ton, cheaper supplies from Japan now sell retail at £58-60, with European urea at £64-65. Though some of the Japanese urea has had a rather high biuret content, this is no disability for use in the sugar industry, where the primary concern is cost per unit of nitrogen. As will be seen in Table I., the use of urea is increasing very considerably.

Sodium nitrate and calcium ammonium nitrate (lime-coated ammonium nitrate) are relatively minor fertilizers used in some fruit, vegetable and tobacco areas.

Although imports are now unrestricted, the tariff remains unaltered as follows:

TABLE 1

Showing the production and imports of nitrogenous fertilizers in Australia
(000's tons)

Year	Imports			Production	Estimated Use of Nitrogen in Agriculture
	Ammonium sulphate	Sodium nitrate	Urea	Ammonium sulphate	
1938/39	35.5	10.2	Nil	24.3	12.8
1954/55	35.0	11.7	1.3	78.4	24.0
1955/56	9.5	14.1	2.0	75.3	18.2
1956/57	13.7	11.2	3.5	110.9	26.2
1957/58	20.9	14.4	6.8	118.7	30.6
1958/59	20.0	7.5	9.1	116.5	31.1
1959/60	Nil (est.)	n.a.	15.0 (est.)	103.0 (est.)	28.0
Use made of substance	Wholly to Agriculture	About 2/3 to industrial uses and 1/3 to agriculture	About 3-4,000 tons to industrial use and the balance to agriculture	Wholly to Agriculture	—

Source of import and production data 1954/55 to 1958/59: Commonwealth Statistician.

Nitrate of soda:—

Free from all sources.

Ammonium sulphate and ammonium nitrate:—

Free under British Preferential Tariff.

Dutiable at 7½ per cent. from most favoured nations.

Dutiable at 15 per cent. from other sources.

Urea:—

Free under British Preferential Tariff.

Dutiable at 7½ per cent. from all other sources.

Currently being admitted free under by-law for use as fertilizer, but dutiable for other uses. By-law subject to review March 1961.

Anhydrous Ammonia and Aqueous Ammonia:—

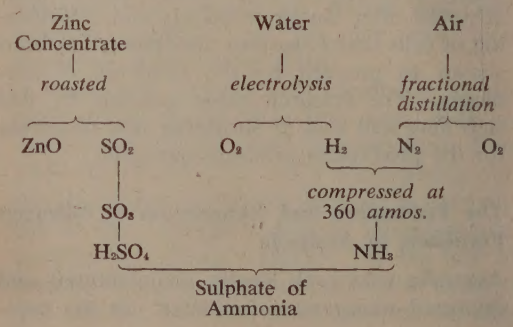
Dutiable at 10 per cent. British Preferential Tariff.

Dutiable at 25 per cent. from most favoured nations.

(No imports of ammonia are being made.)

It will be seen that at present our nitrogen fertilizers are comprised of locally manufactured sulphate of ammonia and of imported urea.

It is of interest to review briefly the Australian production processes for sulphate of ammonia. The Electrolytic Zinc Company has adopted sulphate of ammonia production primarily as a means of utilising the sulphur dioxide evolved during the roasting of zinc concentrates. The process can be summarised as follows:



The expensive item in this process is hydrogen, and countries which have natural supplies of hydrogen have a great advantage in producing cheap fertilizer. The location of the industry in Tasmania adds to distribution costs because of the heavy freight charges around the Australian coast; the cost of shipping fertilizer from Tasmania to Queensland is as great or greater than that of transport from Europe.

The second main source of local production is as a by-product of the steel industries of Newcastle and Port Kembla (about 25,000 tons). Here the process involves the use of the ammoniacal liquor derived in the production of coke for the blast furnaces. Minor production occurs from gasworks (about 5,000 tons of sulphate of ammonia), but most of the ammoniacal liquor from this industry goes to refrigeration. During World War II the Commonwealth Government established synthetic nitrogen plants using a modified Haber process at Mulwala, Albion, Villawood, and Ballarat, for munition production. Two of these are now closed but the latter two were sold to private industry and now produce a few thousand tons of sulphate of ammonia in addition to explosives. All sulphate of ammonia produced in Australia is marketed through what is commonly called "the nitrogen pool", a firm which sells all supplies at a uniform price at all main Australian ports, but is itself independent of production.

TABLE 2

The relative price of nitrogen to the farmer in 1939, 1949 *and* 1959.

	1939	1949	1959	1960 (Sept.)
UNITED STATES.				
Retail price of N per lb (U.S. cents)—				
In sulphate of ammonia	9.1	20.4	14.3	
In anhydrous ammonia	—	8.5	8.8	
Price Index (Consumer)	100	171	210	
Relative Price of N				
In sulphate of ammonia	100	131	75	
In anhydrous ammonia	—	55	50	
UNITED KINGDOM.				
Retail price of N per lb (U.K. Pence)—				
In sulphate of ammonia	4.9	6.0	5.6	
Price Index (Retail)	100	142	220	
Relative Price of N				
In sulphate of ammonia	100	86	52	
AUSTRALIA.				
Retail price of N per lb (Aust. pence)—				
In sulphate of ammonia	6.7	9.4	18.1	14.8
In urea	—	—	—	14.0
Price Index (Retail)	100	147	290	300
Relative Price of N				
In sulphate of ammonia	100	94	92	74
In urea	—	—	—	70

Notes— (a) Relative prices in each country based on N in sulphate of ammonia in 1939 = 100. (b) U.K. values shown as 1939 and 1949 are for 1940 and 1950. (c) U.S.A. values shown for 1939 are 1935-39. (d) U.K. farmers subsidised in 1959 from 10.8 pence to 5.6 pence. (e) N contents assumed to be: sulphate of ammonia 20.6%, urea 46% and anhydrous ammonia 82%. (f) the Australian price index for 1960 is estimated.

TABLE 3

A comparison of the cost of nitrogen to the farmer and of the price received for his products in several countries; values in Australian pence.

Country	Cheapest Form of N	Cost of N to farmer Pence per Pound	Return for Wheat (March, 1960)		Return for 1st Grade Beef (March, 1960)		Return for City (Fluid) Milk (Season average 1959/'60)	
			Pence per Bushel of 60 lb	Ratio: Bushel of wheat to lb of N	Pence per lb carcase (dressed) weight	Ratio: lb of beef to lb of N	Pence per Imperial gallon	Ratio: Gallon of milk to lb of N
England (Reading)	Sulphate of Ammonia (20.6% N)	7.1 (Subsidy of 6.5)	220 (including subsidy of 20)	31/1	40.6 (including subsidy of 4.6)	5.7/1	46.8 (guaranteed season average)	6.6/1
Holland (Wageningen)	Nitrochalk (15.5% N)	15.6	249 (guaranteed to 238)	16/1	40.7	2.6/1	38.1 (guaranteed season average)	2.4/1
U.S.A. (California)	Anhydrous Ammonia (82% N)	9.5	196 (National support price)	21/1	50.9	5.4/1	61.2 (guaranteed season average 3.8% fat)	6.4/1
Hawaii	Anhydrous Ammonia (82% N)	9.7	No wheat grown		52.7	5.4/1	Not available	
New Zealand (Palmerston North)	Sulphate of Ammonia (20.6% N)	19.5	202	10.4/1	19.5	1.0/1	36	1.8/1
Australia (Melb./ Adel.)	Urea (46% N)	14.0	180	12.9/1	23.4	1.7/1	40	2.9/1

The Price of Nitrogen

Table 2 shows the trend in the price of nitrogen within each of three countries during the past 20 years. In the United States the low production cost of anhydrous and aqua ammonia from the hydrogen of natural gas and refineries has been a factor in reducing the price of other forms of nitrogen, but prices still vary considerably as shown by the following figures for the wholesale prices per pound of nitrogen in 1959.

Anhydrous ammonia	5.2 c.
Aqua ammonia	6.1 c.
Ammonium sulphate	7.8 c.
Urea	11.8 c.
Sodium nitrate	13.2 c.
Calcium cyanamide	13.9 c.

Anhydrous ammonia constituted 21 per cent. of all sales for the year, and nitrogen in this form is now available at half the real price of nitrogen in the U.S.A. in 1939. (Ammonium nitrate, price not shown, is another important form of nitrogen in the U.S.A.)

In the United Kingdom the price of nitrogen to the farmer is very low not primarily because of competition between forms but because of the extremely heavy subsidy — amounting in 1959 to 48 per cent. of the cost of sulphate of ammonia to the farmer. In Australia the real price of sulphate of ammonia remained little changed from 1939 to 1959, but the competition of Japanese urea has led to a price drop of nearly 25 per cent. in the past 12 months.

These prices indicate the influence of competing forms and of increasing supplies in bringing down the price of nitrogen. They do not however enable an effective comparison from one country to another because not only the price of fertilizer, but also the price of farm products varies between countries.

In Table 3 an attempt is made to present the ratio of the cost of nitrogen to the selling price of various products in several countries. Inevitably there are limitations in the precision of these comparisons but the overall picture is valid. Some remarkable contrasts emerge. The wheat/N ratio ranges from 10/1 in New Zealand to 31/1 in the United Kingdom, where wheat is subsidised up and nitrogen is subsidised down. The differences for beef are even greater, again with New Zealand lowest at 1/1, and with the United States highest at 5.4/1. Similar ranges are shown for fluid milk. In all cases Australia occupies an intermediate position, but is usually among the lower values.

These ratios provide the main component governing profit and impose a prime influence on the use of nitrogen (N.Z. very low nitrogen consumption, U.S. very high). Nevertheless there are other factors involved, because Holland with rather low ratios is a heavy nitrogen user. These other factors are discussed in a later section.

Synthetic fertilizer nitrogen is already influencing much of the agriculture of the world. There seems some prospect that the downward trend in the price of nitrogen will continue, and that cheap nitrogen may well be a principal factor enabling increased production from world agriculture in the next few decades.

Nitrogen on Temperate Pastures

It is convenient to deal first with temperate pastures even though they provide the least clear-cut role for the use of fertilizer nitrogen. This is because an alternate course of providing nitrogen is available through the growth of legumes. No uniformity of practice occurs between regions, as can be illustrated from three temperate countries. In New Zealand there is complete dependence on legumes and no fertilizer nitrogen whatever is used on pastures. In Holland the average application of nitrogen to all permanent pastures is about 80 lb per acre* over the whole country; most pastures are of grass, with clover absent or of minor importance. In the United Kingdom emphasis is laid both on the role of clovers and on the usefulness of fertilizer nitrogen. These differences have developed in countries of somewhat similar climate and where much the same species are used in the pastures. We can recognise at least five factors which may influence the use of clovers or fertilizer. These are:

a. The success or failure of clover in the environment and the responses to nitrogen.

* All references in this paper to rates of application of nitrogen are expressed as elemental nitrogen and not as rate of fertilizer.

b. The price of nitrogen, including the effect of subsidies, already discussed.

c. The use to be made of the sward.

d. The other factors of the environment, especially soil fertility and rainfall.

e. The intensity of extension work and of commercial propaganda.

These factors are discussed below, but because they are so inter-related all are reviewed together.

In many temperate countries clover has contributed enormous quantities of nitrogen to the pastures and to the economy. For example in southern Australia (south of lat. 29°S) the use of clovers on poor soils is not only increasing livestock production to a spectacular degree but is also converting the soils to new levels of fertility. This contribution of soil nitrogen can be computed with tolerable accuracy since it has been shown by Cook (1939) and Donald and Williams (1954) that the nitrogen increment has linear relationship to phosphorus application and approximates to 84 lb of nitrogen per hundredweight of superphosphate (10.3 lb P). The value of the contribution can be computed as follows:

Mean annual area of topdressed pasture 1936-60 = 12,400,000 acres

Mean annual application of superphosphate = 117 lbs per acre

Total quantity of superphosphate applied in 25 years = 16,100,000 tons.

Increment in soil N per hundredweight of superphosphate = 84 lb N

Total increment in soil N from 16,100,000 tons superphosphate = 12,100,000 tons

Increment in soil N expressed as sulphate of ammonia = 60,500,000 tons

Value of the increment in soil nitrogen contributed by the legumes of the topdressed pastures of southern Australia, 1935-1960, with nitrogen at 14 pence per pound = £1,600,000,000

The current rate of addition of soil nitrogen on 25 million acres of topdressed pastures is of the order of 1 million tons of nitrogen per annum, worth about £130,000,000. In addition there are the substantial quantities of nitrogen provided through pasture legumes in cereal rotations, which are not included in the foregoing estimates. There is not the least doubt that this input of thousands of millions of pounds worth of nitrogen has been the principal contributory factor to the rising production from Australia's agriculture.

The increment of 84 lb of soil nitrogen per hundredweight of superphosphate is based on measured changes in soil nitrogen over a period of years and is far less than the nitrogen actually fixed by the legumes each season, since losses occur by volatilization, leaching and the removal of products. Various estimates of the nitrogen fixed by clover have been based on the amount of nitrogen which must be applied as fertilizer to a pure grass sward in order to give a yield equal to that of a grass-clover mixture, or as by Sears (1953) on a comparison of the nitrogen harvested in grass-clover versus unfertilized grass (see Table 4).

These contributions of nitrogen are so substantial that it seems logical to make full use of pasture legumes in all environments in which they are successful. Yet the temperate countries which do this, without any use of fertilizer nitrogen are few indeed — in fact perhaps only New Zealand and southern Australia.

Clearly if clover cannot be grown successfully, then there is a *prima facie* case for the use of nitrogen, and this circumstance immediately provides a large part of the explanation for liberal nitrogen use in Holland. On the heavy river clays clover growth is notoriously poor and the practice of using nitrogen on these soils has tended also to be adopted on other less difficult soils where clover can in fact be grown satisfactorily. In New York state, Kennedy (1958) bases his recommendations for the use of nitrogen on the amount and vigour of the clover; he advocates the use of some 60 lb nitrogen on all-grass sod, only 25 lb nitrogen where there are moderate amounts of legumes and none on vigorous grass-clover mixtures with over 20 per cent. of clover.

However some countries with good clover are using nitrogen and obviously other factors must be involved. Certainly there are several advantages of nitrogen-fertilized grass, compared with clovery swards. There is a virtual

TABLE 4

Nitrogen contributed by clover expressed as lb N per acre per annum.

1.* U.K. (from Jealotts Hill (1956-7)) mean 1954-5-6.	
With white clover	
Based on yield dry matter	135
Based on yield protein	195
2.* U.K. (from Green and Cowling (1960)) mean 3 years.	
With white clover	
Based on yield dry matter	140
Based on yield protein	200
3.* N.Y. State (from Kennedy (1958)) mean 1952-7.	
With white (ladino) clover	
Based on hay yields	70
4. Iowa (Scholl, private communication) mean 1958-9.	
In Dactylis swards	
Based on dry matter—alfalfa as legume	200
Based on dry matter—red clover as legume	150
5. N.Z. (Sears 1953).	
With white clover	
Warmer northern areas of N.Z.	400-500
Colder southern areas of N.Z.	200-250
6. Pennsylvania (Washko and Marriott 1960).	
Orchard grass and brome grass swards	
Based on dry matter—alfalfa as legume	approx. 300
Based on dry matter—white clover as legume	approx. 150

* Derived data.

elimination of bloat hazards — but on the other hand nitrate poisoning and vaguely defined grass tetany are more likely. Another advantage of pure grass pastures is that they require less skilful management than do grass-clover swards in which it must be an objective to maintain the botanical composition within arbitrary limits. Grass in the mixed sward cannot be allowed to grow too tall or it will eliminate the clovers by shading. This is particularly evident when swards are left ungrazed and it places a limit on the elasticity of use of grass-clover for other purposes than grazing. The system of "zero-grazing", which involves cutting and carting the whole of the fodder for direct feeding to stock or for conservation as silage, and in which the stock never graze the sward, is clearly less suited to a grass-clover economy than to pure grass, fertilized with nitrogen. Even the discontinuance of grazing for shorter periods, as for a single silage cut, a hay cut or especially for grass seed production will usually so depress clover as to require a subsequent management aimed specifically at restoring the proportion of legumes.

The comparison of greatest interest is that of grass-clover and grass-plus-nitrogen under normal grazing or frequent defoliation. Here there are theoretical reasons why pure grass may exceed grass-clover in its production, though as yet these are inadequately understood. First, a substantial weight of substrate materials in the clover must be consumed as energy for nitrogen fixation. This may be of the order of 20 units dry matter per unit of nitrogen (Bond 1941) so that if 100 lb nitrogen were fixed, as much as a ton of dry weight may be lost. (In turn this point may be reduced in significance because the relationships of time, leaf area and growth of the sward are by no means linear — (Donald and Black 1959). Secondly, grass may have a greater potential yield in any given light environment

TABLE 5

The influence of fertilizer nitrogen on a grass/clover sward (Linehan and Lowe, 1960).

lb N/ac/ann.	0	35	70	140	210	350
Per cent. clover	36	28	21	7	1.3	0.3
Yield of herbage (cwt. d.m/ac/ann.)	59	60	62	68	78	93
Yield of protein (cwt./ac/ann.)	10.1	9.9	9.3	10.1	11.3	16.6
		Replacement of clover nitrogen.			Net increase in supply of nitrogen.	
Net recovery of applied nitrogen	—	—10%	—21%	0%	+10%	+28%

than clover, because grass foliage tends to erectness, whereas that of clovers tends to be horizontal (Brougham 1958; Warren Wilson 1960). Again, this point is not adequately resolved. Thirdly, experience shows that when a mixed sward is given nitrogen, the grass always responds in growth; it follows as a reasonable deduction that in any grass-clover sward the grass is suffering some degree of nitrogen deficiency. Or stated in alternate terms, clover only grows under conditions of such partial nitrogen deficiency as will restrict grass growth and admit light to the clover. But again, this proposition cannot be regarded as proven. In the field there is no consistent picture of greater production by fertilized grass than by grass-clover. In some instances the effect of nitrogen application at low levels is to depress yields or at least to give no increase and this is because of reduction of the clover and thus of its nitrogen contribution. When the clover is eventually eliminated, further applications of nitrogen may give very substantial increases in production. This relationship is well illustrated in data (Table 5) from Northern Ireland (Linehan and Lowe 1960).

Net nitrogen recovery of this kind is unlikely to be economically sound, even when it is extremely cheap, as in the United Kingdom.

Results in environments in which clovers

TABLE 6

A comparison of yields from unfertilized grass, fertilized grass and grass/clover — all figures are 3 year means.

Country & treatment	Grass	Grass + N	Grass-clover
	lb/acre dry matter.		
N.Z.[1] (+ N = 620 lb N/ac/ann.)	2,200	10,500	11,500
U.K.[2] (+ N = 210 lb N/ac/ann.)	1,300	7,870	6,230
U.K.[3] (+ N = 70 lb N/ac/ann.)	2,263	4,430	6,861

1. Sears (1960).
2. Green and Cowling (1960).
3. Herriott and Wells (1960).

are particularly successful show that even when grass is given massive doses of nitrogen there may be no marked increase in the dry matter production over a grass-clover sward. Three recent examples are cited in Table 6.

No adequate explanation seems available at the moment for the eventual increase beyond the grass-clover yield at very high levels of nitrogen in some instances and not others. However this relationship will no doubt be considerably affected by management or by any factor which reduces the effectiveness of nitrogen fixation by the legumes, such as molybdenum or other nutrient deficiency.

Nevertheless the picture has a consistency to this point — that when clover development is good, an increase in total yield of the pasture is unlikely with light or moderate applications of nitrogen (up to say 100 lb nitrogen which is heavy by Australian standards) but in some circumstances a very liberal dressing may give substantially increased yield. This sort of finding has led some U.K. workers (e.g. Watkin 1954) to the viewpoint that an all-or-nothing policy should be followed in the use of nitrogen — that it should not be applied at a light rate all over the farm. A majority of fields should carry grass-clover, while special areas are sown to pure grass (e.g. Italian ryegrass) and heavily fertilized with nitrogen.

Animal performance on good grass-clover swards and on grass-nitrogen swards have as yet not often been compared but in the following instances the differences are slight.

1. Washko and Marriott (1960)
   Liveweight gain of steers.
   lb/steer (2 seasons)
   On grass/legume 314
   On grass + 150 lb N. 302

2. Eyles (1959)
   Liveweight gain of sheep.
   lb/acre (1 season)
   On grass/legume . . . 326
   On grass + 108 lb N. . 260
   Herbage cut for silage.
   100 lb/acre (1 season)
   From grass/legume . 37.7
   From grass + 108 lb N. 35.7

On the whole, the evidence of gains in livestock production due to nitrogen fertilizer on grass in regions with good clover development must be regarded as unsubstantiated. In these circumstances the considerable use of nitrogen on the pastures of many progressive farms in the United Kingdom, where clovers generally grow well, may seem surprising. In many instances the objective of the application of nitrogen is to increase growth at the beginning and end of the season, when clovers are making little contribution and grass can be stimulated by nitrogen. The "early bite" induced at the beginning of the season is regarded as being of particular value. In addition the application of nitrogen at these times is less likely to give such a heavy grass development as to suppress the clovers completely. In other instances however, complete replacement of clover nitrogen is adopted.

There are certainly two other factors which greatly influence the use of nitrogen fertilizer on pastures in the United Kingdom. The first of these is the extreme cheapness of fertilizers to the farmer, (though not to the nation), a cheapness which induces an almost prodigal use both of nitrogen and of other nutrients, often with inadequate reckoning of response and profits. The second factor is the great influence of fertilizer firms in promoting the use of nitrogen; certainly the visitor gains the strong impression that commerce has more influence than have disinterested research and extension agencies.

A factor of particular relevance in Australia is the fertility level of the soil. With very low nitrogen status legumes depend almost wholly on rhizobial activity and will fix a maximum quantity of nitrogen from the atmosphere. On the other hand legumes growing on fertile soils depend in considerable measure on the soil nitrogen and much less on fixation. It is for this reason that legumes achieve their most marked success early in land development programmes on poor soils, as is evident in southern Australia.

In summary it seems that the use of fertilizer nitrogen on temperate pastures is an unattractive or doubtful proposition as a complete substitute for rhizobial nitrogen in areas where clovers do well and where the pastures are maintained as grazed swards. On the other hand fertilizer nitrogen can be profitable on temperate pasture where the clover is weak, where the swards are subject to forms of fodder production leading to the elimination of clover by shading or where the pastures are used for special purposes such as 'out-of-season' production.

Nitrogen on Pastures in The Tropics and Sub-tropics

Nitrogen deficiency occurs on nearly all pastures of the tropics. Though leguminous species are numerically abundant in these regions they rarely provide a useful proportion of the pastures, which are commonly wholly of perennial grasses. Here the potential increase in production through cheap nitrogen is enormous, so great in fact as to change the world outlook for meat production to a material degree.

A notable example of this potential production from sub-tropical grasslands can be cited from the Gulf States of the United States where many legumes are of marginal worth but none has proved sufficiently useful to be widely planted. On the contrary the most notable contribution to the species picture has been a grass, bred by Burton (1954) at Tiflis, Georgia. Coastal Bermuda grass (*Cynodon dactylon,* known in Australia as couch grass), is a variety with erect habit and with productivity greatly exceeding that of "common Bermuda grass", already abundant in the region. Coastal Bermuda grass produces little seed, yet no less than three million acres have already been sprig-planted in an arc extending from Virginia southward to Florida and west to East Texas. The successful use of this grass has been dependent on the application of fertilizer nitrogen.

In an irrigated trial in East Texas (Fisher and Caldwell 1959) the annual yields of hay (6 cuts per annum) over a four-year period with nitrogen applied in split doses as ammonium nitrate were as follows:

Nitrogen (lb/ac/ann.)	Yield (lb hay/ac/ann.)
0	5,200
200	11,800
400	18,400
600	22,000
1,180	26,800†
1,800	20,600

†Peak yield.

This remarkable yield of 26,800 lb of grass hay may well be the highest recorded in the literature; even if the moisture content were 15 per cent. the yield of dry matter would be 22,800 lb/ac/annum.

In dry land studies by the Texas Research Foundation (Longstaff 1959), 100 lb N after each cut increased the yield of Bermuda grass from 3.8 to 8.4 short tons with an 80-85 per cent. recovery of nitrogen. The cost of protein was 2.5 cents per lb compared with 7.5 cents in bought supplements. A detailed costing study is also available from Louisiana. (Weigman and Chandler 1959). With nitrogen at 12 cents per lb and grass hay at $25 ton, the increase in yield from 420 lb of nitrogen per acre (2.6 to 7.3 tons) gave a net profit of $45 (£A20) per acre.

These tremendous yields with applied nitrogen—all given in split doses—are possible in these regions for two reasons—a generally satisfactory rainfall and a high light intensity. In a study in Georgia, Burton (1959) showed that with full daylight, an application of 1,600 lb of nitrogen gave a much greater yield than did 200 lb; with 64 per cent. daylight the yields were equal; and at lower levels of light the yield was greater with the lighter dressing of nitrogen. It is because of the high light intensities of the tropics and sub-tropics, often with moderate to good rainfall, that these regions are so critically important in raising agricultural production.

The final study which may be quoted on the use of nitrogen on Coastal Bermuda grass in the Gulf states involved a comparison over

TABLE 7

The influence of nitrogen on fodder production and liveweight gains at Tifton, Georgia (Stephens and Marchant 1959).

Rate of Nitrogen (lb/acre)	50	100	200
Airdry forage (lb/ac/ann.)	4,450	6,990	11,180
Stocking rate (beasts/acre)	1.31	2.11	3.34
Daily liveweight gain (lb/animal)	0.97	1.03	0.96
Liveweight gain per acre (lb/ann.)	256	425	620

a seven-year period (1950-56) of liveweight gains by beef cattle. The data are summarised in Table 7.

This is impressive evidence of what can be achieved on pure grass swards with nitrogen. In both this study and an earlier one (Burton 1954), over two pounds of liveweight were gained for each lb of nitrogen. Some 50 per cent. of commercial beef producers in this region use some nitrogen, but in markedly sub-optimal quantities in nearly all instances. The outlook for the use of nitrogen on grass in this region has been aptly expressed by the remark "The result *could be* about the same as if you uncapped some oil wells in East Texas and then doubled the price of oil".

These results were obtained in a region with relatively high beef prices and low nitrogen prices (Table 3) and they cannot be translated to other economic environments without major qualifications. Nevertheless there are undoubtedly many tropical and subtropical regions in which exactly similar responses can be secured in terms of dry matter production and of beef production and it is important that current economic circumstances should not impede the gathering of response data on these acutely nitrogen-deficient pastures of a great part of the earth.

Nitrogen and Cropping Practice

On some exceptionally fertile soils heavy and continuous cropping is maintained with no use of fertilizers. But usually some positive step to maintain available nitrogen to the crop has proved necessary. The use of organic fertilizers, especially farmyard manure, has commonly given both a satisfactory nitrogen supply and a stable agriculture. On the other hand the bare fallow, though initially giving much increased yields because of increased availability of nitrogen, has often been disastrous in the longer term because of accelerated soil exploitation, with consequent wind and water erosion. In order to remedy this damage many younger countries have adopted rotations involving less cropping and especially the inclusion of leguminous leys. In Australia this use of clover leys has been notably successful in our cereal areas and has contributed to a 50 per cent. increase in grain yields. Does this mean that pasture leys are essential in all circumstances? Though this is probably true in the drought-susceptible cereal areas of Australia, there are many regions of the world, and perhaps some in Australia, in which very intensive and even continuous cropping can be maintained without soil deterioration. And here nitrogen fertilizers are playing a principal role in permitting satisfactory levels of organic matter and soil structure and in enabling a marked increase in crop yields.

Leeper (1938) developed a simple equation to express the equilibrium level of organic matter in soils and this formula had been widely adopted by later workers (e.g. Wood-

ruff 1949, Smith *et al.* 1954, Walker 1956). It is here conveniently expressed in the form of a nitrogen equilibrium as follows:

$$N_E = \frac{k_2}{k_1}$$

where N_E = nitrogen level at equilibrium.
k_1 = the loss of organic nitrogen in in crops and stock and by mineralisation, denitrification and leaching, expressed as a fraction of the whole.
k_2 = added nitrogen from outside sources.

N_E and k_2 are in the same units, e.g. lb nitrogen per acre.

For example, Smith *et al.* (1954) working on the black soils of Texas showed that the original level of organic matter is 5 per cent. After 20 years, with an average yield of 29 bushels and with no definite decline in yield, the organic matter fell to 2.5 per cent. They calculated the equilibrium value of organic matter and the equilibrium yield of grain under continuous cropping. The rate of decline of the organic nitrogen is 1.5 per cent. of the amount present each year, and 20 lb nitrogen is provided annually by rainfall and by non-symbiotic micro-organisms. Hence:

$$N_E = \frac{20}{.015} = 1330 \text{ lb nitrogen per acre}$$

= approx. 1.3% organic matter.

Since each bushel of corn requires 1 lb of nitrogen, they estimated that at 1.3 per cent. organic matter the yield from continuously cropped corn with residues returned would be sustained indefinitely at 20 bushels per acre.

But this is an unattractive proposition on a soil of such high natural fertility. By increasing the input of nitrogen, with a corresponding increase in the volume of crop residues returned to the soil, a substantially higher equilibrium value of soil organic matter and of crop yields can be sustained under continuous cropping. In this instance the addition of sufficient nitrogen (60 lb/annum) to raise the yield to 50 bushels per acre, would so increase the crop residues as to maintain the surface soil organic matter at 2 per cent. with corresponding improvement in water intake and aeration.

And this is exactly what is happening in many favoured parts of the world under the influence of cheap nitrogenous fertilizers. At the present time many of the fences and hedges of the East Anglia region of England are being removed, and the farms are becoming solely crop farms, without livestock. This is possible because of several factors — the liberal guaranteed prices for crop products; the availability of new crop varieties with greater potential for yield; tractors and implements which enable more efficient tillage; weedicides which reduce the tillage; and fertilizers, especially nitrogen, which raise yield and increase the plant residues returned to the soil. This sort of agriculture is anathema to most Australian agriculturists but it can be quite sound and stable under suitable conditions.

A second example may be quoted from the favoured parts of the U.S. prairie, the corn areas of such states as Iowa and Illinois, where farmers can and do operate continuous cropping without livestock or only with corn-fed pigs or feed-lot cattle. Again the emphasis is on heavy fertilization (100-125 lb nitrogen per crop), minimum tillage or plow-plant techniques, band sprays so that only one cultivation will be needed, and an adequate population of plants to exploit the high level of nitrogen supply. Economic studies in this region have shown that farm income depends mainly on the intensity of corn production.

In Australia the climatic and soil environments in which continuous cropping is the best form of land use may be few, but where present land use approaches such a pattern (eg. corn on the Atherton Tablelands) fertilizer nitrogen can clearly contribute to the stability of production by permitting a higher equilibrium level both of soil organic matter and of crop yields. It should similarly be recognised that the present use of nitrogen on sugar cane not only raises yields but also makes a positive contribution to the maintenance of organic matter and soil structure. We should dispel

for all time the idea that the use of nitrogen means soil exploitation.

Where clover leys are providing a heavy input of nitrogen, the need for fertilizer nitrogen on the crop will be limited, but in any circumstance in which the equilibrium tends to be low — even though continuous cropping is not in use — nitrogen can help to give a more productive and stable land use.

Nitrogen Level, Seed Rate and Crop Variety

It is generally known that the more favourable the conditions for plant growth, the greater the population of plants needed to exploit the environment fully. With the advent of cheap nitrogen in the United States, seed rates have generally moved upwards, partly based on experimentation, partly on farmers' experience. A notable study of this relationship (Lang, Pendleton and Dungan 1956) showed that at a low nitrogen level the maximum yield of corn (75 bushels/acre) was given by a population of 12,000 plants per acre; at a moderate nitrogen level the maximum yield (92 bushels) was given with 16,000 plants; while at high nitrogen the peak yield (118 bushels) was not achieved until the population was raised to 20,000 plants. A typical corn belt recommendation to farmers is that with the use of 100 lb of nitrogen per acre, they should change their spacing from 3 plants per hill at 40 in. x 40 in. (12,000 plants per acre) to 2 plants per hill at 20 in. x 38 in. (16,000 plants per acre). In Australia we should re-examine our crop seeding rates, which are often based on experiments of twenty or more years ago, and which may be below the optimum on farms where fertility has been raised by clover leys or fertilizers.

Another interesting consequence of the improved nitrogen status and higher population densities in corn crops has been the reassessment of varieties for this changed environment. For example until a few years ago nearly all the mid-west U.S.A. corn varieties were bred to give one stalk per plant, each with one ear, when planted at 12,000 plants per acre. Now that higher rates are indicated it has been found that the varieties (hybrids) re-act quite differently to changing crop density. Some varieties remain single stemmed even at very wide spacing and conversely show a considerable proportion of barren plants when heavily crowded. On the other hand some varieties are multi-stemmed, with multiple ears per stem at very low densities; when planted thickly these varieties though reduced to a single stem still produce an ear on nearly all stems. This is the type of plant being selected for use at the high levels of fertility made possible by nitrogen fertilizers.

Undoubtedly we face this same problem in Australia — the need to develop varieties suited to our rising levels of fertility (Russell 1957). These varieties need such characters as strength of straw in cereals, but in particular they must have the capacity to exploit the higher fertility in terms of yield. As nitrogen fertilizers and leguminous leys are adopted more widely, it is essential that selection in crop breeding programmes should be made at the level of fertility at which the new varieties are likely to be grown — just as must be done with any other component of the environment.

The Use of Nitrogen in Australia

Of the fertilizer nitrogen used in Australia almost half is devoted to sugar production and the balance to horticultural crops — fruit and vegetables. There is virtually none used on either field crops or pastures. In comparing this position with other countries Russell (1957) emphasises the relatively high cost of fertilizer nitrogen in Australia, the availability of suitable legumes, the effectiveness of legumes on poor soils, the mild winters which make it unnecessary to accumulate large stocks of fodder for the hand feeding of livestock, and the small proportion of intensive arable agriculture.

Yet the fact remains that when judged by our use of nitrogenous fertilizers, Australia is one of the backward agricultural countries of the world. Is such a judgement a fair one?

In southern Australia it seems certain that legumes will continue to play the principal

role in the provision of nitrogen for pastures on initially poor soils — that is, for most of our soils. Our post-war agricultural development and our general economic expansion would not have been possible without the contribution of legume nitrogen — the purchase of even 25 per cent. of this nitrogen as fertilizer would have been beyond our financial resources. But where legume growth is poor or where grass growth can be advantageously stimulated at particular seasons, the use of nitrogen can be well worth while, as shown by Strang (1960) for the parts of the coast of N.S.W. There are also sound economic prospects for the use of nitrogen on winter cereal fodder crops in these areas, either sod-seeded into winter-dormant swards or sown on cultivated ground (Strang 1960, Crofts 1959). The raising of the whole level of fodder production in irrigation areas (Russell 1957) is another prospective use of nitrogen. But clovers are likely to continue to be the dominant source of the nitrogen at least until we have reached or approached the equilibrium level of organic matter on our southern soils. We must then determine the extent to which bag nitrogen can profitably supplement the soil nitrogen supply, but before southern producers abandon their clovers they will need more convincing evidence of the value of bag nitrogen over clover nitrogen than is at present available overseas.

When we turn to the pastures of northern Australia, the outlook is dramatically different. Though many legumes show promise for this region, the fact remains that the only sub-tropical or tropical pastures of the world with adequate nitrogen are the few on very rich soils or the few that are being heavily fertilized with nitrogen. A considerable programme of work is in train on the development of pasture legumes for the cattle regions of sub-tropical Queensland and there seem good prospects of success. Economically this may be the ideal solution. But work on legumes in no way reduces the urgency of the sister programme on the use of nitrogen on grass, a programme at present receiving but scant attention. Table 2 shows the downward trend in the price of nitrogen, and it is reasonable to hope that a continuation of such trends, perhaps combined with rising beef prices may make nitrogen profitable on our northern beef pastures. Little is known of the response curves in terms of yield and composition of the many available grasses in the several sections of this region, of the effects on the soil, of the value of such pastures in animal production, or the possible nitrate toxicity at high nitrogen levels. Work along these lines should not be based on immediate economic gains — it should aim to assemble technical data. Only nitrogen can move these beef areas from their production doldrums, and it is logical that both fertilizer nitrogen and legume nitrogen be fully explored.

The role of nitrogen in our cropping is still undefined; though it has come into fairly general use on our more intensive crops, the lack of use of nitrogen on cereals contrasts vividly with Europe and North America where applications of 20-100 lb of nitrogen are normal. Where legumes are growing well in cereal rotations and where almost the whole of the nitrogen is returned as animal excreta and plant residues, it seems that the total nitrogen level of the soil can be maintained at a wholly satisfactory level. In this circumstance the profitable use of fertilizer nitrogen will probably be confined to those seasons in which the level of nitrate nitrogen is low at seeding or during the winter, due to inadequate nitrification (short or dry fallow period) or due to the loss of nitrate by heavy leaching rains. Where legume growth in the leys is poor, or where leys are precluded by the small size of the property or by other economic factors, total nitrogen is being steadily depleted and here fertilizer nitrogen has immediate prospects of profitably raising yields.

The prejudice which has existed in Australia against fertilizer nitrogen is rapidly passing and we may hope that legume nitrogen and bag nitrogen will each receive objective appraisal. The problem of cost is very much more difficult, but the pressure of falling world prices is reflected in Australian prices and this will certainly increase consumption. On the other hand local nitrogen manufacturers may well feel that their young industries should be protected against ever cheaper imports. This approach would have disad-

vantages since it would tend to suppress the expansion of demand and production which in turn can contribute materially to decreased costs.

The increased use of nitrogen in Australia is of great importance and it would seem a wholly sound policy to subsidise the production or sale of locally produced nitrogen, as was done for superphosphate on pastures in the thirties, though a scale as generous as that in the United Kingdom may not be desirable. At the moment we have not enough information to define the potential use of cheap nitrogen and it is a matter of some urgency that experimental work be pressed forward irrespective of the economics of its immediate commercial application.

The future of the synthetic nitrogen industry in Australia poses many queries. Should we engage in the production of urea, a concentrated nitrogenous fertilizer of versatile uses, as well as sulphate of ammonia? What cheap hydrogen sources can be exploited or developed? In what circumstances is it necessary or unnecessary that the nitrogen be accompanied by sulphur as it is in ammonium sulphate? There are both engineering and agronomic problems in our future production of nitrogenous fertilizers.

Despite these problems it may be hoped that fertilizer nitrogen will have as great an impact in Australia as it is having in many other countries.

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Letters

Dear Sir,

Mr. Angove's address which you published in the September 1960 issue is heartening and interesting. Such objective and vigorous approaches are needed.

I feel sure, however, that the difference stated of £100 between salaries of graduates and non graduates in extension work in the South Australian Department of Agriculture must be an error. Surely the difference is several times greater, or did Mr. Angove have his tongue in his cheek?

Must the other benefits of four year's university study be the main compensation for studying? Or perhaps I should accept more fully his assurance "that money alone is not the sole crterion of life".

Yours, etc.,
R. H. BROWN (W.A.)

ONE HUNDRED YEARS OF ANIMAL PRODUCTION IN QUEENSLAND

P. J. SKERMAN

Queensland's live stock production has come a long way since Patrick Leslie, retracing the trail he had established a few months earlier with his brother Walter and twenty-two men, shepherded his sheep, bullocks and horses to found Queensland's first sheep station at Toolburra on the Condamine on July 2, 1840.

This set in train a wave of pastoral settlement which was well advanced at the time of separation and brought with it the era of squatting which was later to bring knotty problems in land administration.

When Governor Bowen proclaimed the new State of Queensland on December 10, 1859, the Western boundary was on the 141st parallel and the area in round figures some 560,000 square miles. In his 1861 report the Registrar General states — "I must here congratulate the Colony on the recent receipt by His Excellency the Governor of Her Majesty's Supplementary Commission, extending the N.W. boundary of Queensland from the 141st to the 138th meridian of East longitude." This gave us an additional 118,600 square miles to add the Georgina, Mulligan and Diamantina Channel System, a slice of the Barkly Tableland and unwittingly, then, the great mineral fields of Mt. Isa and Mary Kathleen.

The report goes on to state that "It will be seen from the above figures that Queensland is by far the most extensive of the British Colonies: it possesses an area nearly double the area of Canada, and if compared with European States is one-half larger than England, Ireland, Scotland, Wales, France and Spain all added together: it is in fact nearly equal in area to one-fifth of the area of the whole of Europe and its dependencies. Pastoral occupation (then totalling 195,000 square miles) has already spread over a surface twice as large as that of the British Isles and it is annually advancing onward at a rate which will soon place our stockowners on the shores of the Gulf of Carpentaria."

At the time of separation from New South Wales Queensland's live stock totalled 3,166,802 sheep, 432,890 cattle, 23,504 horses, and 7,147 pigs; while only 3,353 acres of land were under cultivation. White population as at December 31, 1859 was estimated at 25,020 plus some 10 - 15,000 aboriginals.

The Custom's return of wool, tallow, hides etc., the produce of the above live stock exported during the year 1860 were as follows:—

Dr. P. J. Skerman is Senior Lecturer in Agriculture at the University of Queensland. *This review is a record of his Presidential Address to the Queensland Society for Animal Production on June 20, 1959.*

	Quantity	Value	Average Value
Wool	5,007,167 lb	£444,188 9 0	21.29d./lb
Sheepskins	705 bundles	3,737 13 0	£ 5 6 0/bundle
Tallow	640 tons	25,628 0 0	£40 0 10½/ton
Hides	18,976	10,277 1 0	10 10/hide
Salt beef	961 tierces	4,273 0 0	£ 4 8 11/tierce
Horns, hoofs, calf skins, tongues etc.		962 15 0	
		£489,066 15 0	

The total value for 1955-6 was £135,000,000

All of the exports were to New South Wales and most went indirectly to Great Britain because of the absence of a Queensland port. This drew the observation from the Registrar-General, Mr. F. O. Darvall — "Owing to our recent position as a dependency of New South Wales our mercantile transactions still continue to be, to a great extent, centred in Sydney: a large portion of our flocks and herds are mortgaged to Sydney merchants and to them is, therefore, consigned the great bulk of our exports, and from them is received in return nearly the whole of our imports. A connexion of this kind cannot be severed at once, and so long as it exists, our direct commerce in the Great Britain must be very small. New South Wales will not only make a large profit out of the produce of our flocks and herds, but will also get the credit of being larger consumers of British manufactures than is true, and we, on the contrary, must remain liable to misrepresentation. A more serious evil arises, however, from this state of things and that is the position in which it places the producers of our staple exports. We are thereby rendered dependent upon the solvency of New South Wales merchants and commission agents. This, to say the least of it, is not satisfactory."

On the brighter side he reported that — "live stock and its products, such as tallow, wool, hides and horns, are the main, and at present it may be said, the only productive interest of the Colony. On our pastoral prosperity depends almost entirely our revenue and our trade and to it we are indebted for our wealth, and for our great and rapidly increasing powers of consumption of British manufactures." If we turn to our table of exports we see there wool, tallow, hides, horns etc. forming 93.5 per cent. of the whole exports of the Colony; the importance therefore of the pastoral interest can hardly be overestimated.

The Sheep Industry

At separation Queensland sheep numbers totalled 3,166,802. The distribution of this flock is interesting as the Gayndah district led with 506,066 sheep followed by Condamine and Warwick, Dalby and Rockhampton. The large numbers of sheep on the coast at Rockhampton and Gayndah were soon to dwindle because of the occurrence of foot rot, spear grass and worms. The Archers shifted their Gracemere flock to Minnie Downs, Tambo in 1872.

Mr. Frederick Bracker, a stud sheep expert in Germany, is really the founder of Queensland's stud sheep industry, the Leslies having brought only flock sheep to Toolburra on July 2, 1840. Bracker brought sheep from the flock of Baron von Baer of Mecklenberg in 1828 for Bettingtons' Brindley Park stud and selected sheep from here to found the North British Australian Company's Rosenthal stud at Warwick in 1840. Later he founded his own stud at Warroo, Inglewood.

In 1835 John Deuchar selected 100 ewes from Rosenthal to found the Glengallan stud and in 1860 brought ten rams and ten ewes from the flock of Baron Von Maltzahn in Mecklenberg. C. H. Marshall brought out

another consignment in 1862. "Deuchar Billy" purchased by Deuchar for the Gammies of Talgai and later taken over by him had tremendous influence on the early Queensland flocks. On Deuchar's death Mr. Slade took his place as a partner with Marshall and continued the development of the stud.

In 1853 the Eton Vale stud was founded by Hodgson and Watts with Brindley Park sheep and later, introduced Spanish, Silesian rams and Steiger rams. These mated with the Glengallan sheep built up a good flock. In 1856 Welltown stud was founded by J. & W. Lon. The Pikedale stud was started by Mr. Donald Gunn in 1865 and East Talgai by George Clark in 1867. These studs laid the foundation for the Queensland sheep industry.

The first slump in sheep occurred about 1854 when diseases, particularly foot rot and scab, caused havoc in the flocks. These troubles coincided with extreme labour shortages as shepherds, boundary riders, teamsters and shearers left the north for the Gold Rush in Victoria. However, one of the first pieces of legislation of Queensland's infant Government, "The Scab and Other Diseases in Sheep Prevention Act of 1860" was to levy sheep owners 5s. per 1,000 sheep to provide a fund to fight foot rot and scab. By 1864 scab was controlled and foot rot on the Darling Downs was stamped out by 1870.

The history of Queensland's sheep and wool industry would not have been so satisfying had not the discovery and development of the Great Artesian Water Basin taken place. Sheep cannot walk long distances to water and would have been excluded from the vast area of Mitchell grass and Mulga country where only intermittent seasonal stream flow occurred. The first deep bore was completed in the Cunnamulla district in 1887. By 1914 a total of 1,229 artesian bores had been drilled, the discharge at the date being some 351 million gallons a day and by 1952 some 2,309 bores were in action. The total flow now is some 230 million gallons a day, the decline being due to loss of elastic storage causing loss of pressure and loss of flow. Ultimately a steady state will be reached when the amount of recharge will equal what is being withdrawn from the basin. The findings of the Artesian Committee in 1954 was that artesian diminution is a disability but in no way threatens the future of the pastoral industry. The high cost of boring and possibly the occurrence of fluoride and the post war development of heavy tank sinking machinery have turned graziers attention more to storage in excavated tanks.

Coincidental with the discovery of artesian water was the development of the shearing machine. Frederick York Wolseley had a workable machine patented in 1877 and, with the help of L. B. Park and later John Howard, progress was good enough to demonstrate his machine at the 1887 Queensland Jubilee exhibition in Brisbane.

Following the tracks of the explorers Leichhardt, Kennedy, and Mitchell, Queensland's sheep lands were rapidly opened up. Drought of course became an ever-present hazard, the 1901-2 one being particularly drastic (19½ million sheep dwindled to less than 7¼ million) with other serious ones in 1915-16, 1926, 1935-40, 1946, 1951-2 and now the present 1958-9. The depression years of the 1930's coupled with the drought years left the industry in a serious plight, the price falling to as low as 8.36d. per lb in 1930-31. In 1939 Mr. Payne was appointed Commissioner to enquire into the economic condition of the Wool Industry in Queensland.

During the two World Wars, Government acquisition of the clip and later gradual release to consumers helped to keep prices satisfactory to the benefit of the industry.

The application of science to the sheep and wool industry has done much to keep it in the forefront and the high prices during the boom in the early fifties have allowed graziers to implement these findings and carry out necessary station improvement to increase efficiency. In 1936 the Australian Wool Board was formed with finance levied at 6d. per bale for research and Gilruth Plains Field Station, Cunnamulla came into being.

The development of blow-fly repellants, the Mules operation, the partial destruction of the rabbit by myxomatosis, worm control, and ram classing are all the result of the application of scientific research and have added

inestimably to wool production. In this connexion reference should be made to the good work of Dr. George Moule, as Director of Sheep Husbandry, and his officers in his vigorous extension campaign to familiarise graziers with latest scientific findings and encourage them to use them.

The introduction of progeny testing of rams and fleece weighing and testing is a modern development and one which is proving its worth in improving our flocks.

Drought has always been the scourge of the sheep and wool industry and our average lambing percentage has remained static largely because of it and its allied heat waves. Drought mitigation in the form of fodder conservation is receiving our attention now and exhaustive tests on hand feeding, using low quality roughage with supplements, is being done by various bodies, notably by Dr. Franklin of C.S.I.R.O. in Sydney. Sheep numbers reached an all-time high of 25,650,231 in 1943 but by 1947 the total had fallen to 16,084,340 and five years later, in 1952 the state could only muster 16,163,519 sheep.

The Beef Cattle Industry

Queensland's beef cattle numbered 432,890 in 1860. The increase was rapid until 1894, when thirty-four years after separation the number had increased to 7,012,997. From that date, partly in consequence of periods of drought, partly from ticks in the coastal districts, and from the large numbers of cattle slaughtered for meat export or boiling down for tallow, the number at the end of 1899, was just over 5,000,000.

The early cattle were of the English Durham breed which later became the Shorthorn. Glengallan was the first Shorthorn stud established in Queensland. It was founded by John Deuchar in 1842 on cows purchased from the Australian Agricultural Company and later passed into the hands of Mr. Marshall. The herd was enriched by importation of the best British blood and in those early days the value of good mating was exemplified when "Red Duchess" 13th was taken 600 miles each way to be served by Dr. Jenkin's bull "Theodore" at Nepean Towers. The trip was worthwhile as the calf, "Lady Theodora", won six championships and was never beaten in the showring.

In 1876 Mr. W. B. Slade joined the partnership and under his management the herd developed magnificently and from 1876 to 1902 Glengallan was not only the biggest Shorthorn stud in Australia with 2,000 breeders but the property of 40,000 acres had 1,300 acres of lucerne and 300 acres of prairie grass!

The late David C. McConnel of Cressbrook is justly regarded as the greatest improver of the Shorthorn in Queensland and proceeded to import the best blood available. The herd was disposed of in 1885, most of the stock going to Messrs. A. A. Dangar and Bell of Noorindoo.

Canning Downs founded by Hon. J. D. Macansh in 1873 and Warroo owned by Harry Bracker were also early studs, the latter building up a large clientele for herd bulls. Of interest is the record of a pedigree Shorthorn herd on Monkira — way out on the Diamantina — in the eighties. Nappamerrie on the Lower Cooper was taken up by Conrick and Ware in 1871, just a few years after the fateful Burke and Wills expedition.

One of the most famous early bulls was "Lyndhurst Royal Peer", bred and owned by C. E. McDougall, and he was a frequent winner of the Brisbane championship. A massive roan, he was exactly the type required for the old Queensland breeders who wanted "walkers" and marketed their heavy bullocks with a fair amount of age on them.

In 1901 Shorthorns constituted 80 per cent. of the beef cattle of the state and Herefords 15 per cent. — mostly "grades".

Early pure bred Herefords were those of Durundur Estates at the head of the Stanley. Hon. William Allen's herd at Braeside, Warwick and the Archers of Gracemere, Rockhampton. Well known grade herds existed on Lammermoor and Lyndhurst in the Cook district owned by Barnes Estates. Mr. William Hogarth of Balgownie introduced the Aberdeen Angus and a few Devons early found their way into the state.

The commercial meat market had its early worries and yet it shows how little we have

progressed in some directions. In 1891 there were eight meatworks operating but by 1896 thirty-five had come into being. Of live cattle slaughtered in 1896, 77,719 were preserved (canned), 76,483 were frozen and 87,562 boiled down for tallow and meat extract. In the Report of the Registrar-General for 1901 we read:—

"The producers complain that the prices they realise are totally out of proportion to the retail price of meat on the market, and imply that the middle man makes altogether too much of the transaction: these in turn complain that while much of Queensland meat is excellent yet there is a want of grading at this end and consequently that some of the carcasses are not only much inferior to British meat, but fall short of that imported from America, where the cattle are fattened on maize, and it is, moreover, asserted that greater care is taken with the get-up of the meat and that the unevenness in quality adversely affects the sale of all meat shipped from the Colony. It is now generally admitted that frozen meat is not equal to freshly killed or even to chilled meat and unless a means can be discovered which shall be found a sufficient preservative to protect meat during the long and hot voyage from Australia without absolutely freezing it, it does not seem possible to rival in appearance either the English fresh or the American chilled meat."

"Continuity of supply is an important point in connexion with meat export. Should the output in time of drought prove unequal to maintain the acquired trade, the market secured at the expenditure of much trouble would be promptly appropriated by other meat producing countries and on the return of more favourable seasons would need to be re-won."

The advent of the cattle tick to Queensland from the Northern Territory around about the year 1895 spelt a major disaster for Queensland cattle industries and has over the years meant many millions of pounds loss from cattle, meat, and hides and is still the cattle industry's foremost problem. It is pleasing to see the present intensive effort by C.S.I.R.O., the State Department of Agriculture and Stock and the University to mitigate its effect.

The breeds of cattle have undergone considerable modification since these early years. The Hereford has gained the greatest popularity though the Shorthorn still reigns in the western and north western areas. The hardy but leggy types have disappeared from most areas and the age of turn-off has been considerably reduced by better breeding and feeding. Polled-ness has come to stay, the first polled Herefords being introduced to Queensland by A. H. Stirrat of Euroa, Mt. Larcom, and Hon. Jas. Sparkes M.L.A. of Lyndley, Dalby, whose record as a breeder of fat cattle must be unequalled throughout the Commonwealth.

It was in response to an effort to minimise the tick problem as well as to obtain a breed of beef cattle with heat tolerance that Dr. R. B. Kelley of C.S.I.R.O. introduced bulls of the Zebu or Brahman race in 1933 and started a new era in beef cattle production in the tropics. These were crossed with local cattle in North Queensland and over the years numerous offspring have shown a degree of heat and tick tolerance which has improved the cattleman's hopes in the north. The improvement of beef quality is still being sought and recent weighing trials by the Department of Agriculture and Stock and C.S.I.R.O. have shown the great advantage in growth rate of these hybrid cattle. Extensive breeding experiments at the C.S.I.R.O. National Cattle Breeding Station at Belmont are intended to test crosses suitable for tropical conditions. The recent introduction of Santa Gertrudis animals from King Ranch, Texas, carrying American Brahman blood and with more impressive beef producing qualities will hasten this development on private holdings. The Droughtmaster cattle are also being popularised. The introduction of cattle weighing by the Department of Agriculture and Stock has been a major contribution to intelligent cattle husbandry.

The cattle industry has always had difficulty with prices and in 1923 because of a slump in prices the McCormack Government introduced a Cattle Relief Scheme to readjust cattlemen's rents until re-assessment in 1936.

This Government was also concerned with the prickly pear which was strangling the cattle

areas and constituted the Prickly Pear Land Commission in 1924 giving it jurisdiction over 65,000,000 acres of which about 26,000,000 acres were practically valueless.

On the production side we have seen improved pastures gradually replacing the native species. In the far north Para grass, guinea, molasses and Rhodes in combination with centro, stylo, puero, and *Glycine javanica* are being used. On the poorer and drier country Townsville lucerne has spread naturally. Further south in the spear grass country Shaw has introduced guinea, centro, phasey bean and lucerne. In the hinterland we have rhodes, buffel grasses, green panic and lucerne with new C.S.I.R.O. species of *Sorghum almum, Phaseolus atro-purpureus* etc.

Crop fattening on oats, sudan grass and lucerne has also come to stay where cropping is possible and a young, well bred store can be topped off for the market.

With low dairy prices there is a new interest in vealer production using a beef bull, particularly on the tail end of the herd. Transport developments have been slow. Cattle trains have not speeded up very much and rolling stock is often short. Road trains have helped out in the far west and the Sea-beef scheme in Cape York Peninsula has helped develop the cattle industry there.

The Dairy Industry

The early development of dairying in Queensland centred around the Darling Downs and Moreton districts and the coastal portion of Wide Bay. Butter was made by hand and there was insufficient for local needs. It was early thought that Queensland's climate was too unfavourable to export dairy produce successfully and compete with southern states.

The commencement of the expansion of dairying dates from early 1889 when the Queensland Government introduced a system of travelling dairies and the manufacture of butter and cheese on a scientific basis was practically demonstrated by experts. Foremost among these was John Mahon who played a leading part in the early development of dairying and later, as Principal of the Gatton Agricultural College, he sponsored better cattle, herd testing, better feeding, clean milk production, scientific butter and cheese making, marketing of a quality product overseas, and distributed pure bred sires to the industry at reasonable prices.

In the year 1889 Queensland imported 781,422 lb of butter at a cost of £35,041 and 1,274,310 lb of cheese for £31,853. By 1895 the importation of butter had practically ceased and exports exceeded imports for the first time in 1897. In 1899 some 8,462,595 lb of butter was produced of which 1,159,255 lb was exported and 11,358 lb of cheese was also exported. From a mere half dozen separators in the Colony in 1889 and no factories worthy of the name, a total of 204 butter factories and 131 creameries were reported for 1898. In 1895 not quite a quarter of the total output was factory butter — by 1896 the proportion was 53 per cent. The first important cheese factory was erected at Yangan in 1893 and the first important butter factory at Allora in 1897.

In 1895 the first experimental shipment of cold stored butter from Queensland was made when 7½ tons were shipped to London and arrived in excellent condition. In 1900 a larger shipment of 63 tons were sent away in S.S. Jumna and to quote "the reports on its quality on landing gave ample assurance that Queensland can hold its own in the world's market for dairy produce". The butter was packed with space between each layer of boxes, thus allowing a free circulation of air and the temperature kept at 35°F. A sample box from each consignment to form a "control" was placed in railway refrigerating stores at Roma St. and opened fifteen weeks later in excellent condition.

A Meat and Dairy Encouragement Act levied funds from dairy and cattlemen and this allowed advances to be made to co-operative companies and assistance to the export trade. The co-operative manufacture of dairy products in Queensland was commenced in 1901 when the Queensland Farmers' Co-operative Company was formed and started operations with a butter factory

at Booval. Subsequently, practically the whole of the Queensland butter and cheese factories become co-operatively owned. At first boats called every six weeks but soon a fortnightly service was established with Sydney from whence the butter was transhipped to London.

The cattle used in Queensland's early dairying history included the long established breeds, the Jersey and Ayrshire with a few Guernseys. Holsteins (later to be known as Friesians) and the south coast cattle which were being developed in New South Wales around Kiama and later became the Illawarra Milking Shorthorn and now the Australian Illawarra Shorthorn. The development of the Australian Illawarra Shorthorn in the herds of the Coles, the Greys, the Dudgeons and others in the Illawarra district of the south coast of New South Wales calls for special mention as one of this breed, "Melba XV of Darbalara", established the world production record with 3,170 gallons of milk and 1,164 lb of butter in the year 1921. This world record held for many years and the figures still constitute an Australian record. The A.I.S. breed of cattle has made its mark in Queensland dairying to the extent that only once in 38 years has a representative of this breed not won the Royal National Champion Butterfat Test. Last year "Sunnyview Little Princess 20th", bred and owned by J. Phillips and Sons of Wondai, in a bid to break Melba XV's record gave 1,053 lb of butter fat in 300 days but death overtook her before completion of the lactation.

The Dairying Division of the Queensland Department of Agriculture and Stock was established under the Dairy Produce Act of 1904 and provided for the inspection of dairy farms and dairy factories. As these officers so appointed were really advisory officers anxious to help the farmer the term inspector was recently dropped and replaced by adviser. These officers have played a large part in the general expansion and efficiency of dairying.

Queensland dairying was to benefit greatly from a series of developments in the southern states. The first was the invention of Mort's successful refrigeration system which enabled butter to be preserved and exported without deterioration; the second was the invention and importation into Australia of the cream separator to replace hand skimming of cream and the third was the introduction of the milk and cream tester invented by Professor Babcock of Wisconsin, U.S.A.

The earliest dairying advisers advocated herd testing and the Department of Agriculture and Stock made its officers available to dairymen to undertake testing for owners on a voluntary basis. Unfortunately, most of the dairymen who took advantage of the scheme were stud-breeders anxious to have production figures to back the sale of stud sires, and the commercial dairyman exhibited little interest except in purchasing bulls, made available under a subsidised scheme by the Government for progeny of tested dams. An Advanced Registry of Production was established and cows qualified for entry into this register by producing at least the minimum production set down for each age group over the specified time. There was a tendency for breeders only to submit portion of their herd for testing but later the Department of Agriculture has insisted on testing of the entire herd. In 1948 a Group Herd recording scheme was introduced to encompass both stud and grade herds, again on a voluntary basis, and this has greatly improved production in the herds concerned.

In 1955 the Department of Agriculture and Stock introduced large scale artificial insemination services to the dairying industry and using bulls proved under the Bull Proving Scheme at Nambour and Atherton. This advance should bear fruit in increased production from future herds. The figures for production per cow in Queensland over the years do not give cause for jubilation. From a study of the graph of average production it is obvious that the major declines occur in periods of severe drought. This would indicate that feeding is the answer to sustained and high production. I am satisfied that genes for high production exist in most herds but these genes cannot find full expression because of inadequate nutrition. In the long history of dairying in Queensland this is the most unsatisfactory aspect of the whole industry. In addition to the ever recurrent but irregular drought periods the annual dry spring months take their toll of production. Our dairymen must look on this period as an annual "must" for supple-

mentary feeding just as our British forebears lay in store for their snow bound winters.

The indigenous pastures of the state have carried the great bulk of our dairy stock and because of the seasonal nature of growth, ceasing about April and not recommencing till early summer, nutrition has been inadequate for a large portion of the year. Quite early in the state's dairying history, however, attention was drawn to artificially sown grasses and in 1901 John Mahon made reference to the fact that the grasses most favoured at that time were prairie and *Paspalum dilatatum*, both of which had been found excellent for the production of a large flow of milk. Paspalum showed a great liking for the cleared rain forest country of the Blackhall range near the North Coast and even as far north as the Atherton Tableland, and its initial productivity on relatively virgin soil rated this grass very popular amongst dairymen. As the fertility of these scrub soils declined under continuous grazing with little return of organic matter and nitrogen, paspalum pastures lost their popularity and their sod bound condition, their frost susceptibility, and the later appearance of ergot, made dairymen switch more and more to kikuyu with a longer productive period and less susceptibility to frost. On the brigalow and softwood scrub soils rhodes grass from South Africa found a natural home and this grass played a significant part in the development of economical dairying in the hinterland, until its productivity, too, declined. The search for sown pastures for the Darling Down self-mulching black soils was less rewarding and so dairymen turned to fodder crops — settling mainly to sudan grass in summer and oats for winter grazing.

The Dairy Industry Extension Grant money has enabled more intensive research and demonstration in improved pastures and improved practices.

Dairymen had been faced with inadequate prices for their products on the export markets since the early 1920's. The first major move towards stabilising the butter industry was the introduction of the Paterson Scheme in 1926. Under this scheme contributions collected on total manufacture created a fund from which a bounty was paid on all butter exported. This helped initially but the benefit decreased as production expanded. Fluctuations on the London market and interstate competition gradually disrupted stability and declining prices in London led dairymen into desperate straits. An Equalisation plan emerged from the crisis in May, 1934 controlled by the industry itself and local prices then were fixed independently of the London market and this has been the main stabilising factor in the dairying industry. Queensland leaders Chris Sheehy, Jim Purcell, Tom Plunkett, and Jim McRobert played a major part in bringing this plan to fruition.

Various attempts to unite dairymen to press their claims for more remunerative prices culminated in the successful formation of the Queensland Dairymen's Organisation in 1941. Pressure from these organisations and interstate support led to the cost-of-production surveys conducted by the Commonwealth Bureau of Agricultural Economics and the industry for the first time was paid in relation to production costs. This enabled dairymen to plan improvements at the production end and, although dissatisfaction has recently been widespread because of the attitude of the Commonwealth Government in fixing a subsidy limit which does not enable full production costs to be handed on to the farmer, this organisation of dairymen has proved worthwhile as a forum for industry problems.

The recent menace of margarine has focused attention on sales promotion and an intense drive to improve dairying efficiency by reducing costs to compete more favourably with this product has been undertaken. New uses for milk and its products such as the introduction of milk powder into bread, the supply of free milk to school children, the production of ghee, the greater variety in cheese production, are all making their presence felt on the home market and dairy technologists are seeking further useful and remunerative outlets.

In addition to the improvement in the volume of production there has been a marked increase in the quality of dairy produce. With Queensland's higher temperatures and consequent greater risk of spoilage it has been

necessary to pay particular attention to production. The early introduction of pasteurisation was a starting point followed by vacreation to remove feed flavours. On the farm the adoption of milking machines and more recently the introduction of farm refrigeration by the Queensland Butter Board has greatly improved keeping quality. The Queensland Department of Agriculture and Stock has helped with its Butter Improvement Scheme and its dairy machinery investigations with the cleaning of milking machines.

Time does not permit of development in the control of diseases but I mention the use of penicillin for mastitis and Strain 19 for the control of contagious abortion.

Pigs

The pig has almost suckled the dairy cow in the history of the state's pigraising industry and its development has gone hand in hand with dairying. Early pigs were generally of the shorter and fatter types with heavy jowl and an overabundance of back fat. But over the years the public demand for lean meat has become so insistent that penalties are now incurred for the over-fat pig. As a result breeders have dispensed with the heavy jowl and gone for a longer, leaner pig. The ton litter contests with Gloucester Old Spots and Duroc Jerseys in the twenties have been forgotten and the pig has been streamlined. No history of the pig industry in Queensland would be complete without mention of the pioneering and enthusiastic work of Mr. E. J. Shelton who travelled the State far and wide to instruct all ages from children to grandfathers in the art of pigraising, and Mr. R. G. Watson who has been in the forefront of efficient pigraising for many years. The feeding problem has always been an important one both from the point of finishing ability and the cost. The results of Dr. John Hammond of Cambridge have done much to improve feeding techniques and his carcase appraisal system has had widespread support. A Northern Pig Marketing Board has existed since 1923.

The extension of pig raising to grain farms using meatmeal has been a comparatively recent development and its future depends on the grain : pork price ratio.

Pig housing and sanitation has improved, diseases have been controlled. We still waste too much skim milk in pig feeding which could be used elsewhere.

The recently established Pig testing Station at Rocklea will open up a new era to breeders wishing to evaluate their stock.

Horses

The number of horses in Queensland in 1860 was 23,504 and in 1899 was 479,127. These comprised 2 per cent. thoroughbred, 56 per cent. saddle, 38 per cent. light harness and only 4 per cent. heavy draught. The foundations of the horse stock in Australia were laid on importations from the Cape of Good Hope and some excellent Arabs from India.

The discovery of gold led to an unprecedented demand for draught stock and cross breeding with light horses gave a nondescript light draught for this purpose.

A demand sprang up for remount horses for Indian Army purposes and in 1896 it is recorded that 886 horses were shipped to India and 56 to Java. Insurance, freight and cost of feed and attention on the voyage was very heavy and the conditions of acceptance strict.

The development of agriculture called for good type draught horses and some excellent Clydesdale stallions were imported to meet the demand. A number of stallions imported by the Government were placed at Gatton College where mares were brought for service and stallions were sent out to stand the season in the country.

Following World War I the tractor gradually replaced the draught horse and the motor car the light harness horse, and today the horse population is found in mustering camps, on the race-track, in the showring, and on dude ranches. School buses are quickly replacing the school pony and the day of the rural horse is passing. This is one of the tragedies of modern living as the love of man for his horse has been traditional.

Goats

Goats have long been the source of milk and "mutton" in western towns and also the town

scavengers. Breeding indiscriminately they have built up in numbers and then have been subject to a periodical "blitz". Always hard on country the goats have denuded vegetation and become a local nuisance and now that pasteurised milk in refrigerated rail cars is reaching these towns the goat population is declining. Some councils bought pedigree bucks to improve the stock from time to time.

A new cottage goat industry is developing nearer the coast, where the goat can provide milk for a family and utilise backyard forage of various kinds, and the introduction of stud goat classes, mostly the Saanen, at the R.N.A. shows this recent trend.

Poultry

Records of early poultry production are rather meagre. In the early days of the 20th century egg laying tests were provided under the Supervision of the Department of Agriculture and Stock and these enabled breeders to obtain high producing stock. Feeding trials came later and the propounding of rations from the most economical sources of grain and meals became big business when the economics of production were at stake. The introduction of the Egg Marketing Board in 1923 helped to stabilise marketing and the opening of the Poultry Abattoir fairly recently has helped dispose of surplus stock. The new Departmental Poultry Testing Station at Rocklea is a further step in improving the state's flocks and breeding and management studies are well advanced. The introduction of A.I. has given 93 per cent. fertility over the 85 per cent. on the average natural mating. The use of a high energy diet has given greater production on less feed. In 1955 there were 810 commercial poultry flocks, egg production for the state was 9½ million dozen and the per capita consumption 203 eggs.

Bees

Bees generally come under the banner of live stock although I always think of them in terms of entomology. Queensland's beekeeping industry is a comparatively recent development although individual beekeepers have operated for a long time. The formation of the Honey Board stabilised marketing and gave beekeepers a voice in the industry affairs. Queensland's heat probably restricts the range of beekeeping but not the enthusiasm of the beekeepers and the recent introduction of artificial insemination of bees at Gatton College shows that there is a good deal of interest in improving the industry. There are about 800 commercial beekeepers in the state.

General

The live stock industries of the state are on the threshold of a new era. There has been a marked improvement in the knowledge of genetics, of disease control, of nutrition — a growing population to feed — and a real interest in the improvement of our pasture land. The influx of scientists from other states and the increased enrolment at our University in the rural sciences will join the pool of local scientists already achieving visible results in all aspects of live stock production.

The younger generation of producers, through better education at the secondary schools, agricultural colleges and in Junior Farmers Clubs field days, are eager to get on with the job and if they wisely combine the experience of their fathers with their new learning we may look forward with confidence to the future.

There is a growing appreciation of costs and the immediate future will see a more balanced approach to live stock economy — considering each property as a whole and integrating production enterprises so that greater efficiency can be obtained.

Queensland has a great future and the live stock industries are still among her greatest assets. We must keep them so.

THE POSSIBILITIES OF INDUCING TWINNING IN CATTLE

D. R. LAMOND and
W. T. CLARK

A considerable amount of interest has developed in this country in the current twinning experiments in Great Britain conducted under the auspices of the Milk Marketing Board, some preliminary results of which have recently been published (Anon. 1959).

Practical methods of increasing the proportion of twins would have advantages for both beef and dairy cattle producers. In particular, production of vealers on dairy farms would be greatly simplified, since the dairy herd could produce calves suitable for veal in addition to normal herd replacements.

The major practical objections to twinning are the occurrence of free-martins and increased risks at parturition. Free-martins may be expected in approximately 90 per cent. of heifer twins to bulls. However, this is not important in maintaining normal commercial breeding cow numbers since for every two females born as twins to males, approximately one pair of normal female twins can be expected. Free-martins, however, reduce the value of twinning as a means of increasing selection potential. Untoward sequels to twinning have been shown to assume significant proportions (Cloringer and Thoele 1957) which may influence farmers to limit induction of twins to the inferior cows in the herd. Nevertheless, although twinning may be welcomed by cattle breeders there is as yet no obvious method by which it can be brought about.

The most promising methods of inducing twinning at the present time are those based on the use of gonadotrophic hormones. Selection for twinning also offers some hope, but little is known of the progress which can be made (Erb and Morrison, 1959). In this paper some factors which influence the use of hormones in obtaining twin calves are discussed.

Relationship between Twin Births and Ovulation Rate

Normally cows have only one calf per gestation, but twins occur in approximately one calving in 30 in dairy cattle and one in 100 in beef cattle (Asdell 1955; Meadows and Lush 1957). There are considerable differences between strains and breeds.

It is well known that under normal conditions a proportion of fertilised eggs do not develop into embryos. An accurate account of pre-natal losses of embryos has not been possible with present techniques but 10-40 per cent. losses have been estimated (Laing 1949; Tanabe and Casida 1949; Stewart 1952; Hansel 1959).

When single ovulations take place in a group of cows the proportion of fertilised eggs which complete pregnancy is higher than when multiple ovulations occur (Kidder, Barrett and Casida 1952; Asdell 1955; Anon. 1959). However, a higher total number of calves is born in multiple ovulated cattle when the

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number of ovulations is limited to two per cow. Increasing the number of ovulations, by hormone treatments, leads to a proportionately greater increase in embryonic loss so that fertility in cattle where more than two ovulations are induced is very low (Hammond 1949; Dowling 1950; Dzuik, Donker, Nichols and Petersen 1958). Hence in the field there does not seem to be anything to gain by ovulating an excessive number of eggs and hoping that the cow will reduce the number to one or two.

Hormonal Augmentation of Ovulation Rate

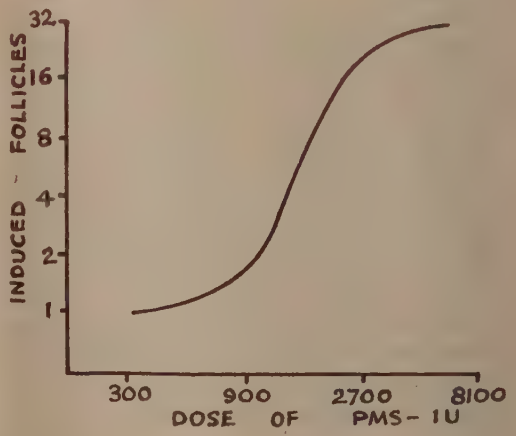
It seems likely that in order to obtain a significant proportion of twin calves in a herd, two criteria must be satisfied. Firstly, only two ovulations should be induced, and secondly, embryonic losses should at least be no greater than in normal single-ovulating cows. In regard to the second factor, it is possible that hormone therapy may eventually be successful but nothing definite is yet known about the causes of embryonic losses in single-ovulating cows, and suggestions for solving this problem would be speculative. Nevertheless, it is clear that in the present state of knowledge embryonic losses following twin ovulations are a major factor limiting twin births.

In inducing twin ovulations four factors must be considered:

Heredity. Ovulation is an all-or-none phenomenon. In a group of single-ovulating cows under similar conditions, we may reasonably expect that the amount of external stimulation required to produce an extra ovulation will vary greatly from cow to cow. Some of this variation will be due to genetic factors, hence while the response itself may be quantal the underlying genetic basis is most likely not.

Environment. Environmental (including management) factors may influence the ovarian response through the anterior pituitary gland (Hignett 1950; Meites 1953). If, as seems likely (Lamond and Emmens 1959), placental hormones, which are most commonly used in multiple ovulation studies, interact with endogenous gonadotrophin produced by the pituitary gland, the response to a given hormone treatment will vary with environmentally induced changes in endogenous gonadotrophin levels.

Hormones. Multiple ovulation can be produced by numerous hormone preparations but the cheapest and most reliable is pregnant mare serum gonadotrophin (PMS). Given under certain strictly defined conditions, i.e., during the follicular phase of the oestrous cycle or at the same time as enucleation of a corpus luteum, small increments in dose of PMS yield disproportionately large increases in numbers of follicles. This is shown diagrammatically in Figure 1, which is derived from data from numerous sources (Hammond 1949; Dowling 1950; Rowson 1951; Anon. 1959; Lamond, unpublished data). Because of the limitations to the available data the errors involved in estimating the position and slope of the curve are not known. The curve is also influenced by the fact that not all stimulated follicles ovulate, unless ovulating hormone is administered. The important point relating to this discussion is that two follicles fall on the steep portion of the dose-response curve. Small changes in the position of the curve because of variation due to genetic and environmental factors thus make it very difficult to select an optimum dose (Figure 1).



Figue 1 — Diagramatic representation of possible relationship between dose of PMS and numbers of induced follicles in cattle.

Practical limitations. In dairy cattle passing through the shed twice daily it is possible to detect oestrus and hence predict the likely occurrence of the follicular phase of the next cycle. This is not possible in beef cattle and some form of manipulation of the oestrous cycle, particularly in relation to ovulation, is required. Techniques of progesterone suppression of oestrus and ovulation are being developed along the same lines as those already used in sheep (Braden, Lamond and Radford 1960; Lamond and Lambourne, unpublished data), in an effort to synchronise ovulation and simplify both the hormonal treatments for twinning (see below) and the use of artificial insemination.

Methods of Inducing Twin Ovulations

From the physiological point of view, one of two steps can be taken to ensure twin ovulations in a high proportion of cows:—either the within-cow and between-cow variation may be reduced or the slope of the dose-response curve may be reduced in the region of two follicles. A purely physical approach might be to induce a large number of embryos and to manually rupture the excess number of amniotic sacs before the uterine reaction takes place (Hammond 1959). This, however, does not appear to be a practical possibility since a high degree of skill is required.

Two methods of reducing variability in response to gonadotrophins are being examined here at the University of New England. Firstly, progesterone is being used to suppress oestrus and ovulation for either 14-16 days in untreated cows or 5-6 days after ablation of the corpus luteum. This technique clearly eliminates day-to-day differences in response and may well reduce variation in endogenous gonadotrophin output and thus warrants full investigation. Secondly, although as yet confined to sheep, an estimate of seasonal differences in response to a standard dose of gonadotrophic hormone is being made.

In reducing the slope of the dose-response curve, two approaches are feasible. It may be possible, after growing a large number of follicles, to give a dose of ovulating hormone which will ovulate only two follicles. Rowson (1951) and Lamming and Rowson (1952) have pointed out that where large numbers of follicles are induced the first few to ovulate produce progesterone which inhibits ovulation of the remainder. At present, however, it seems easier to control the numbers of growing follicles than to control the number of ovulations, at least in small animals (Lamond 1960). Secondly, it may be possible to modify PMS in such a way as to alter its effect on follicular growth. This could be done by simultaneous use of other hormones, by anti-PMS serum or by chemical alteration of the PMS molecule. In this regard, Hammond and Bhattacharya (1944) observed that a moderate dose of PMS given prior to removal of the corpus luteum produced a greater proportion of twin ovulations than when given after ablation.

Summary

On the assumption that a significant increase in twinning rates in dairy and beef cattle is desirable, the present status of hormonal methods of inducing twinning has been discussed. Factors influencing hormonal augmentation of ovulation are genetic, environmental and endocrine. There are also practical difficulties to be overcome in the field, especially in beef cattle. Methods of inducing twin ovulations appear to depend on discovery of ways of reducing variation between and within animals or by reducing the slope of the dose (gonadotrophin)— response (follicular stimulation) curve in the region of two follicles.

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HORTICULTURAL ADVISORY OFFICER (CITRUS)

Horticultural Advisory Officer (Citrus) is required by the Agricultural Department, Auckland, New Zealand. (Vacancy No. 3029).

Duties: Those of a specialist advisory officer acting as liaison between research workers on citrus and field instructors; responsible for the division's experimental work on citrus and undertaking some personal experimental work. Interested in and eventually playing an active part in promoting the citrus industry in New Zealand.

Qualification required: Applicants must hold a recognised degree in horticulture, science or agriculture. Previous experience in citrus and in field experimentation an advantage.

Salary: Salary and maximum will be in the range of £NZ1165 - £NZ1355. Further promotion is on merit as an extension officer to £NZ1800 a year and there are administrative positions beyond this figure.

Applications should be sent in the first instance to the New Zealand Government Senior Trade Commissioner, 14 Martin Place, Sydney, with whom applications close on 30th December, 1960.

Technical Notes

Sampling Errors in the Evaluation of Soil Potassium and pH.

Variations in potassium in a morphologically uniform soil are sometimes large (Craley and Loveday 1958). Further, redistribution of potassium from animal excreta under normal grazing conditions may be responsible for considerable variability in soil potassium.

Raupach (1954) has summarised soil variations in pH over small distances reported by a number of Australian workers, and shows that errors from single determinations may have 5 per cent. limits as high as ± 1.3 pH units.

Soil variations of this kind pose sampling problems when evaluating the potassium and pH status of field plots in pasture experiments. Usually the difficulty is to decide on the number of random sub-samples which should be taken and composited from an individual plot to give a satisfactory sample.

This note reports an investigation into this aspect on a slightly potassium-deficient, podsolic (solodic?) sandy loam in the Bairnsdale district under red-gum woodland and carrying moderately improved pasture grazed by sheep. The area had been topdressed with superphosphate, but not with potash.

Experimental

A site, 90 ft x 60 ft, was divided into two rows, 90 ft x 30 ft, and each row into six plots, 15 ft x 30 ft. In Table 1, plots Nos. 1 to 6 consecutively are adjoining while in rows A and B corresponding numbers adjoin.

Soil samples were taken in late October, 1958 to a depth of 4 inches with a 1 inch core sampler. Ten cores were taken at random from each plot and composited to give twelve plot samples. This procedure was repeated to give a second set of samples.

Determinations of "available" potassium and pH were made on the air dry samples.

"Available" potassium is the potassium in parts per million of air dry soil extracted by leaching with N/20 HC1. Such potassium appears to correlate fairly well with responses of pastures to potash in southern Victorian soils. The potassium extracted is essentially exchangeable potassium. Water soluble potassium is included.

pH was determined with the glass electrode on a 1:5 soil to water suspension.

Results

These are given in Table 1.

TABLE 1

"Available" potassium content and pH of pairs of composited soil samples, 0-4 *in.*

Plot	K p.p.m.		pH	
A1	112	130	6.0	6.1
A2	72	156	5.9	6.0
A3	118	132	5.7	5.7
A4	94	102	5.6	5.6
A5	80	94	5.5	5.7
A6	90	110	5.6	5.6
B1	122	140	5.5	5.6
B2	114	116	5.6	5.7
B3	96	106	5.7	5.9
B4	118	158	5.5	5.8
B5	82	94	5.4	5.7
B6	78	78	5.7	5.8

1. "Available" potassium. The site mean (240 cores) for "available" potassium is 108 p.p.m. and has 2 σ limits of ± 8.5 p.p.m. Moreover, the number of samples (n), each composited from ten cores, required to give specific 2 σ limits of ± X for an area 15 ft x 30 ft is $1735/X^2$. Values of n for some selected values of X are as follows:

X K p.p.m.	n
± 5	70
± 10	18
± 15	8
± 20	5

2. pH. The number of samples required to give specific 2 σ limits of ± X is $0.0516/X^2$.

Values of n for two selected values of X are given below:

X	n
pH	
± 0.2	1.3
± 0.3	0.6

Discussion

In experiments involving soil potassium on this site, treatment effects of less than about 15%, i.e., differences of 16 p.p.m. between means of treatments are unlikely to prove significant unless the means are determined so as to have 2 σ limits of less than $16/\sqrt{2}$. For this, n = 14, i.e., a total of 140 cores per treatment needs to be taken or 140/N per plot where N is the number of replications. This appears to be about the practical limit to sampling intensity in many field experiments.

With pH on this site, the sampling problem is not formidable, 12 cores per treatment mean being required to test differences of 0.3 pH.

The above estimations are minimum sampling requirements since there may be other undetermined sources of error in replicated field experiments which could demand substantially larger numbers of samples for both potassium and pH.

Whilst these results do not have general application, they do indicate that much more intensive soil sampling may be needed than is often done in field experiments. Further, they suggest that sampling to evaluate small or even moderate effects on soil potassium may be quite impracticable in some circumstances.

Acknowledgements

Mr. R. Jardine, Biometrician, provided statistical advice; Mr. J. K. Kehoe, Research Agrostologist, selected the site and took the soil samples; Mr. F. X. Hess, Chemist, did the soil analyses.

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A Cold Incubator

Most fungi are cultivated in the laboratory on the bench at room temperature or in incubators at 25°C. The optimum temperature for growth of the black spot fungus of apples, *Venturia inaequalis* however, is 18°C. Difficulty in maintaining the strain of this fungus at room temperature in the Melbourne summer led us to the following low cost conversion as an alternative to an expensive single purpose incubator.

The temperature control of a second hand electric "Silent Knight" (gas expansion type refrigerator) was replaced by a *Ranco type S. 010 thermostat at maximum cut-in setting and 8°F differential. The sensitive tube of the thermostat was led through the rear of the cabinet and attached to the outside of the freezing chamber. With the refrigerator heater control at medium setting, the cabinet has maintained a temperature of 18°C ± 1°C without trouble. The laboratory temperature has varied from 18°C to 32°C in the nine months of use. The total cost of refrigerator, thermostat, and conversion by a mechanic was £20.

The unit may be operated at temperatures of 8°C to 18°C by varying the Ranco thermostat.

* Australian Controls Limited, 511 Keilor Road, Niddrie, Vic.

A. S. TAYLOR.

ICIANZ Limited,
Merrindale Biological Research Station,
Croydon,
Vic.

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Dispersal of White Wax Scale (*ceroplastes destructor* Newst) by Wind

White wax scale is a commonly occurring scale pest of citrus, persimmon, and many ornamental shrubs in most parts of coastal New South Wales. In addition, it occasionally occurs on other fruit trees, particularly pears, and habitually infests a variety of woody weed plants, notably the Native Blackthorn — *Bursaria spinosa* Cav. The injury caused directly from the sap sucking activities of these insects is of minor importance and the principal damage caused by their presence on the hosts results from the abundant growth of sooty mould fungus or fumagine, which develops on the copious excretions of "honey-dew" produced by the scales. White wax scales become adult and fully grown during the late winter and deposit large numbers of oval, salmon coloured eggs beneath the scale body during the spring months. These eggs usually hatch during November and December, with peak hatching in most districts occurring during the first half of December. The young six legged reddish brown larvae crawl from beneath the parent scale and move around actively over the foliage for a few hours before finally settling along the midrib or beside the main veins of the leaves. The rostralis or sucking tube is then inserted into the leaf tissue and feeding commences. Shortly after this occurs the young larval scale secretes a small white waxy pad on the upper surface of the body and a series of waxy rays around the margins. After feeding in this position for about four to five weeks the larva withdraws the rostralis, moults, and then moves back on to the twig where it settles in its permanent feeding position. There the scale increases in size, secreting wax more freely, firstly as a conical cap of white watery wax and later becoming completely covered with an irregularly oval soft waxy layer.

Control of white wax scale may be accomplished by spraying with solutions of washing soda or soda ash in late summer after the waxy covering has been formed but this method is unpopular on account of plant damage which may follow the use of these caustic sprays. An alternative method of control, where advantage is taken of the unprotected condition of the scales in the first larval stage when they are settled on the leaves to apply a thorough white oil spray, has been demonstrated (Hely and Levitt 1950). Satisfactory results from this method are dependent upon careful timing so that application of the spray is made when the majority of the eggs have hatched and before the second stage larvae have moved back on to the twigs and have commenced to produce the waxy covering.

Field observations have shown that wax scale larvae are capable of being transported by wind during the period between hatching from the eggs and before they have settled on the leaves and have commenced feeding. Measurements taken in citrus orchard blocks which had been skeleton pruned in late winter, and where all wood, likely to bear mature wax scales, had been removed, have shown that wax scale larvae settled on the subsequently produced foliage growth in the following December, on trees distant up to 100 feet from the nearest source of mature wax scale infestation. The available evidence pointed strongly to wind as the mode of transportation of these scales. In this stage the first stage larvae are relatively light and are not burdened with the wax pad and rays which are acquired after settling. Quayle (1916) working in California citrus orchards found that larvae of the black scale, *Saissetia oleae* (Bern.) may be carried by wind for distances of up to 450 feet as shown by capture on tanglefoot treated sheets. He also found that larvae of the red scale *Aonidiella aurantii* (Mask.) could be wind transported for distances up to 150 feet.

As the white wax scale larvae have a second migratory stage when moving from the leaves to infest the twigs, and as no clear evidence of wind distribution at this stage was available, an experiment was set up at the Gosford Citrus Experiment Station, Narara, to endeavour to obtain information on this

point. An open area of about two acres of land planted with trellised American grapevine stocks was selected and in the centre of the area a large freshly cut Valencia orange branch, heavily infested with white wax scale, was supported by a stake lashed to the top of a vine trellis post. The foliage on the branch was from six to nine feet above ground level. At the time of erecting this branch (2 P.M. on December 20), second larval stage scales, equipped with wax pads and rays, were moving back from the leaves in numbers and had just commenced to settle on the twigs. Targets, 9 inches by 9 inches, with one surface smeared with a coating of a mixture of "Ostico" tree banding material and methylated spirit, were fixed to the top of six foot stakes and placed at 20 foot intervals in four directions from the central orange branch and these were supported by the vine trellis wires. The smeared surfaces of the targets faced towards the orange branch.

Observations were made on the target faces and on the nearby grapevine leaves at intervals until January 5, when the experiment was concluded. It was noted that up to December 28, larval scales were active and crawling over the orange foliage although by this time the leaves were severely wilted and curled.

Whilst larvae were observed on only one of the targets, viz., at 20 feet in a south west direction on December 30, an unexpected result occurred in that larvae were seen settled beside the main veins on the upper surfaces of some of the grapevine leaves. The strong contrast afforded between the bright green of these leaves, and the conspicuous white pad and rays of the young scales, allowed these to be detected very readily, and it was possible to determine the extent of distribution with comparative ease.

Dry westerly winds blew throughout the day on December 23, and a cold south easterly wind occurred on December 28, otherwise conditions were generally moderate throughout the period of the experiment.

Second stage larval scales were found on vine leaves at maximum distances of 40 feet in a north easterly direction, 24 feet in a south easterly direction, and at 30 feet in both south west and north west directions from the central orange branch.

At a final inspection of the area on January 5, only a few larval scales were still present in the vine leaves and these were all dead. No scales were found on the canes and it appears that they were unable to survive on this host. From these observations it is evident that wind distribution of larval white wax scales during their second migration period can occur but the area over which they might thus be spread is probably very limited. In terms of average coastal citrus orchard plantings the maximum distance of 40 feet observed in this experiment represents two tree rows. It is, however, quite possible in orchards that trees in outside rows at least could be reinfested, following effective mid summer treatment with oil sprays, from either adjacent untreated orchard trees or from windbreaks or bush trees nearby. In home gardens a similar reinfestation could readily occur from neighbouring untreated infested garden plants or from street ornamental trees which are commonly infested with white wax scale.

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Races of *Phytophthora infestans (mont.)* de Bary on Potato

In recent years a noteworthy feature of the occurrence of races of *Phytophthora infestans* on potato has been the frequent detection of race 4 (Black, Mastenbroek, Mills and Peterson 1953) in the field on potato varieties lacking the genes for immunity derived from *Solanum demissum* Lindl. In some instances, race 4 has predominated over race O in field isolations from these varieties (Graham 1954; Mastenbroek and De Bruin 1955; Doling 1957; Kedar, Rotem and Wahl 1959). Pristou and Gallegly (1956) noted the presence of the race 4 character in isolates of the more specialized races which had not previously been considered pathogenic to the R_4 genotype. Takase (1957) postulated that the resistance conferred by gene R_4 was weaker than that conferred by genes R_1, R_2, or R_3. Gallegly and Eichenmuller (1959) showed that other races could acquire the race 4 character and they considered that this could be due to mutation of nuclei within the thalli. Gallegly and Niederhauser (1959) considered that if the widespread occurrence of race 4 was due to mutation then this occurred much more frequently than did mutation to acquire the race 1, 2 or 3 characters.

In 1957, 1958 and 1959, a number of advanced seedlings, each having as their parents one or other of the blight immune varieties or seedlings referred to by Jessup (1958) in his review of the New South Wales Department of Agriculture's potato breeding programme, were tested for reaction to local isolates of the pathogen, using the detached leaflet technique described by Toxopeus (1954). Sporangia were obtained from cultures maintained in tubers of the Factor variety (r). The sporangia were placed in dishes of distilled water at 15°C for 2 hours and the zoospore suspension so obtained was used to inoculate detached leaflets which had been taken from near the top of actively growing seedlings in a glasshouse. The leaflets were then incubated at 20°C. Detached leaflets of four single gene differential seedlings obtained from Dr. W. Black were included to determine if races other than race 0 were present and a susceptible (r) control (Factor) was also included. The results of inoculations set out in Table I show that an isolate obtained from Gosford N.S.W. and used in 1957 and 1958 was race 0 but that an isolate obtained from Warriewood N.S.W. in 1959 was race 4. Detached leaflets of seedling 1563 (c) 14 and of Factor inoculated with the Warriewood isolate showed profuse development of sporangia in four to five days while detached leaflets of the three other major gene differentials showed a hypersensitive necrotic reaction.

TABLE 1

Reaction of differentials to isolates of P. infestans.

Differential	Gene	Source of Isolate		
		Gosford		Warriewood
		1957	1958	1959
835(a) 4	R_1	—	—	—
1512(c) 16	R_2	—	—	—
1928(e) 2	R_3	—	—	—
1563(c) 14	R_4	—	—	+
Factor	r	+	+	+

The presence of race 4 at Warriewood could not be explained on the basis of culture of R_4 genotypes at or near the locality and it would appear that mutation to include the race 4 character has occurred. The overall distribution of race 4 in New South Wales is not known but in view of the facts presented in recent years the breeding of potato varieties carrying gene R_4 alone would not be warranted in any late blight resistance programme.

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Low Gallonage Application for Pest and Disease Control in Tomatoes

The introduction of concentrate oil misting for leaf spot (*Cercospora musae*) control in bananas (Blake and Chalker 1959) has aroused interest in New South Wales in concentrate spraying for pest and disease control in tomatoes.

To evaluate the efficiency of concentrate spraying for pest and disease control, an experiment was carried out in a trellissed one half acre crop of winter tomatoes, variety Rouge de Marmande, at Murwillumbah, N.S.W., in 1959. In this experiment yields from plots receiving a concentrate oil misting programme, a semi-concentrate water misting programme, and no treatment, were compared.

Experimental

A. Concentrate Oil Programme:
10 oz copper oxychloride (oil miscible formulation)
7 fl. oz 25 percent DDT emulsified concentrate
2 pt unemulsified mineral oil (misting oil)
B. Semi-concentrate Water Programme:
10 oz copper oxychloride
7 fl. oz 25 percent DDT emulsified concentrate
12 fl. oz white oil
2 gal water
C. Control: no treatment
Plot size — 1/25 acre
Note: Rates of application varied according to the stage of maturity of the crop. For treatment (A) rates increased from ½ to 3 gallons per acre and for treatment (B) from 4 to 20 gallons per acre.

The treatments were applied with a portable hand-directed "Motoblo" misting machine at weekly intervals, except DDT which was included each fortnight. Until the bushes reached a height of about 18 inches, mists were applied by holding the hand piece of the machine above the plants and directing the mist downwards into the bushes. Thereafter the mists were applied from both sides of every row.

All mature fruit was harvested from the 12 plots separately, twice weekly and the total weight of fruit from each plot obtained. Fruit was then sorted and the weight of caterpillar damaged fruit determined for each plot.

Results

The yields are given in Table I.
It will be noted that on October 22, approximately 14 days after harvest commenced, yields from the three treatments were similar. From October 22 onwards the yield from plots receiving the semi-concentrate water programme was greater than that from the concentrate oil plots and considerably greater than that from the control plots. The difference between the treatments is most clearly shown in the period from November 11 when the semi-concentrate water plots yielded 2,217 lb of fruit, the concentrate oil plots, 1,227 lb and the control, 348 lb.

Discussion

From the application of the first treatment on July 9, until the experiment concluded on November 23, 27.11 inches of rain were recorded on 56 days, to make the 1959 winter-

TABLE 1

Total yield of tomatoes from treatment plots at different stages in the harvest.

Stage of harvest	Semi-concentrate water programme		Concentrate oil programme		Control	
	Total yield (lb)	Progressive total yield (lb)	Total yield (lb)	Progressive total yield (lb)	Total yield (lb)	Progressive total yield (lb)
Oct 10 - 22	307	307	298	298	374	374
Oct 22 - Nov 11	4059	4366	3001	3299	2203	2577
Nov 11 - Nov 23	2217	6583	1227	4526	348	2925

spring period one of the wettest in recent years. Temperatures were relatively cool with prolonged periods of high humidity. Septoria leaf spot (*Septoria lycopersici*) caused unusually severe defoliation while early blight (*Alternaria solani*) developed with mild intensity. Bacterial spot (*Xanthomonas vesicatoria*), leaf mould (*Cladosporium fulvum*) and the virus diseases, yellow top and leaf shrivel (Potato Virus Y) normally major diseases on the Far North Coast, were practically absent from the crop. A heavy infestation of the caterpillar *Heliothis punctigera* occurred throughout the experimental period as shown by the 45.7 per cent. loss of fruit in control plots (Table 2).

The yield of 6,583 lb of tomatoes from the semi-concentrate water plots (equivalent to 43,450 lb per acre) is 46 per cent. greater than the yield from the oil concentrate plots and 125 per cent. greater than that from the controls. This yield compared favourably with district crops which received Bordeaux mixture and DDT as high volume programmes in the same season. The higher yield from the semi-concentrate water plots was due to better control of disease, the absence of stem and foliage burning and possible interference with

TABLE 2

Yield from three treatments showing replication yields and percentage of Heliothis caterpillar damaged fruit.

Replication	Semi-concentrate water programme		Concentrate oil programme		Control	
	Total yield (lb)	Caterpillar damaged fruit (%)	Total yield (lb)	Caterpillar damaged fruit (%)	Total yield (lb)	Caterpillar damaged fruit (%)
1	1611	9.4	1005	7.2	855	40.4
2	1692	8.3	1051	8.9	690	48.4
3	1619	5.6	1055	7.3	821	38.5
4	1661	4.4	1415	7.5	559	55.6
Total	6583		4526		2925	
Mean		6.9		7.7		45.7

plant vigour and fruit set noted in oil concentrate plots. Considerable defoliation by Septoria leaf spot and early blight occurred in the concentrate oil plots reflecting the inadequate coverage of leaves obtained with a concentrate oil programme.

No difference could be shown between the effectiveness of the semi-concentrate water and concentrate oil programmes in controlling Heliothis caterpillar. The 7 per cent. infestation in both treatments (Table 2) was due principally to invasion from adjacent control plots. The effectiveness of both treatments suggested that deposition of DDT on the flower clusters and young tender terminals where the Heliothis moth lays its eggs had been adequate.

The results suggest that efficient control of Heliothis caterpillar, Septoria leaf spot and mild early blight may be achieved by applying insecticides and fungicides suspended in relatively small quantities of water.

That pests and diseases of tomatoes can be controlled by applying fungicides and insecticides at low gallonages per acre is significant, for it allows portable misting machines which have recently become available, to be used to advantage in tomato culture. This lightweight equipment reduces the cost of control programmes by reducing the time and labour of application. Mists may be applied soon after the cessation of rain and with ease, in plantings established on steep slopes which limit the use of high volume equipment.

No information is available on the efficiency of semi-concentrate spraying for controlling insects other than Heliothis caterpillar which require thorough insecticide application for their control and the diseases bacterial spot, leaf mould, early blight and late blight *(Phytophthora infestans)* under epiphytotic conditions.

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The Time of Maturity of Apples Influenced by Foliar Sprays

From field observations in 1954, it appeared that borax sprays applied to overcome boron deficiency in apple trees had brought about an increased abscission of Granny Smith fruits at the pre-harvest stage and that these fruits were advanced in maturity compared with those from untreated trees. It had been reported by Williams and Veerhof (1948) that boron applied to peaches had hastened maturity and reduced red coloration of the fruit. Later Boynton (1954) found that an excess of boron had hastened maturity and the change from green to yellow in the ground colour of apple fruits. An attempt to change the time of maturity of apple fruits by the application of foliage sprays was made in the seasons 1955-6 to 1958-9.

Treatments and Methods

The treatments compared were as follows:

Control
Borax, 0.5 per cent. solution
Urea, 1.0 per cent. solution
Borax, 0.5 per cent. plus urea 1.0 per cent. solutions.

In the 1956 and 1957 seasons these treatments were applied to blocks of six Jonathan

and five Granny Smith trees at the rate of three gallons per tree. In the 1955-6 season sprays were applied on December 6, and December 29, to both varieties, with an extra application to the Granny Smith trees on March 10. In the following season (1956-7), the sprays were applied on December 27, January 19, and January 31, to both varieties and an additional spray to Granny Smith on February 18.

For the 1958-9 season, a randomised trial was designed using a planting of eight year old Jonathan trees. The four treatments were applied to three-tree plots with ten replications of each treatment. Approximately one gallon of spray per tree was applied on January 8, January 16, and February 2, at 74, 82 and 99 days after full bloom.

In this latter trial samples of ten fruits were taken at random from a chosen tree in each plot at intervals throughout the growing season, and later from fruit harvested on February 27, and held in a cold store. Fresh weight and dry weight of fruits was determined, the acidity of fresh juice obtained by titrating a 10 ml sample against N/10 Na OH, soluble solids in the juice measured by a dipping refractometer. In all seasons the conversion of starch to sugar in the flesh was estimated by dipping the equatorially cut surface of the fruits momentarily into a solution of IKI, and the percentage starch loss expressed numerically using a scale of points where nought equals full blue colour developed over the cut surface and represents 100 per cent. starch present, to six when no blue colour shows and starch conversion is complete.

The Jonathan fruits were picked at the stage when the red colour of the fruit becomes bright and the ground colour changes from green to yellow. These criteria are those used by orchardists and accepted in commerce as indicating maturity.

Results

Maturity and colour change in fruit: The percentage of Jonathan fruits mature at the first pick in relation to the total crop weight is given for the various years in Table 1, where the figures are means of angular transform values.

TABLE 1

Jonathan; percentage of total crop in the first pick. Means of angular transform values.

Treatment	1956	1957	1959
Control	38.27	20.50	19.98
Borax	55.42	28.67	35.85
Urea	17.28	15.02	21.98
Borax, urea	54.30	25.08	43.50
M.S.D. between treatments at 5%	6.45	6.41	3.82

Although the results are not completely consistent, the borax sprays have consistently promoted early maturation of fruit in all seasons. In 1956 urea applied alone retarded maturity and the same trend is evident in 1957, but in 1959 there is no significant effect. On the other hand in the presence of borax, urea had no effect in 1956 and 1957 but a very positive effect in 1959. It is suggested that there is a borax-urea interaction evident in 1956 and 1959, with urea having a less retarding effect on maturity in the presence of borax than in its absence, but that the actual effect exerted by urea either in the presence or absence of borax varies from year to year.

Conversion of starch to sugars, starch test: The results of the starch tests are given in Table 2 for samples of fruits remaining on the trees at the dates shown.

An increased conversion of starch occurred in fruits from the borax sprayed trees and a retardation in starch conversion with urea sprays. There is some evidence of an interaction between borax and urea in 1956 and 1957 and to a reduced extent with Jonathan in 1959. Included in Table 2 is the percentage of the total Granny Smith crop which had abscissed up to the date of the first pick. Abscission of fruit begins at the time prior to normal harvest and is referred to as pre-harvest drop. There is a broad agreement between the loss of starch in the fruits and the severity of pre-harvest drop and it appears that borax is the factor responsible for this increase.

Boron effect on acidity of juice: There is some evidence in the Jonathan trial of 1959 that borax sprays increased the acidity of fruits; the greatest change occurring with the

TABLE 2

Starch tests and fruit drop.

Treatment	Granny Smith Starch 5/4/56	Granny Smith percent crop drop 5/4/56	Starch 29/3/57	percent crop drop 29/3/57	Jonathan Starch test 16/2/59
Control	3.52	5.4	3.19	nil	3.21
Borax	3.93	42.6	4.90	19.3	3.89
Urea	2.73	10.6	2.14	nil	3.44
Borax & Urea	4.32	41.7	5.30	25.5	4.41
M.S.D. between treatments at 5% level	0.51		0.51		0.53

samples taken on February 16, 1959 which was fourteen days after the three sprays had been applied. In Table 3, the acidity of the juice is expressed as the number of c.c. of N/10 NaOH needed to neutralize 10 c.c. of juice. An analysis of co-variance of the data indicates that boron increased acidity between the pre-treatment sample of January 5, 1959 and the sample of February 16, 1959 above the 5 per cent. level.

There was no indication in this trial that dry weight, fresh weight or total soluble solids had been affected by the treatments applied.

Discussion

During the several years that borax sprays have been applied to apple trees, no evidence of boron toxicity symptoms have appeared or indeed any detrimental change in fruit or tree growth. Further as a deficiency of boron is common to this district, it therefore seems that contrary to Boynton (1954) boron need not be present in excessive quantities to produce an early maturing effect in apples.

The application of borax sprays to hasten, and of urea sprays to delay the maturity of apples would be a commercially useful method of extending the harvesting period, particularly in heavy cropping years; this would apply especially to modern orchards where large plantings of a particular variety are made. In such cases the harvest could be planned and perhaps handled by a reduced labour force. As an indication of the changes in harvest time, on January 20, 1960 one hundred trees of Jonathan were sprayed with borax and forty control trees in rows alongside were

TABLE 3

Acidity of juice (c.c. NaOH). Jonathan 1959.

Treatment	Sampled 5/1/59	Sampled 27/1/59	Sampled 16/2/59	Sampled 9/4/59
Control	22.13	19.31	16.13	11.88
Borax	21.83	19.38	17.56	12.09
Urea	21.83	19.13	16.69	11.49
Borax Urea	22.53	20.26	18.13	12.47
L.S.D. at 5%	0.98	0.75 P. < .05	1.06 P. < .001	0.72 P. < .05

untreated. The first pick from the borax sprayed trees was made on February 9, 1960 and the first pick from the unsprayed trees on February 15, 1960. The last pick from the borax treated trees was on February 25, 1960 and that from the control trees on March 11, 1960.

Acknowledgement

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Variation in Disease Reaction within Bean (*Phasedus vulgaris* L.) Varieties

One of the major bean diseases in New South Wales is anthracnose, caused by the fungus *Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav. Under moist conditions, this disease causes quite heavy losses in the field and is also responsible for severe damage to pods in transit to markets. Several physiologic races of the fungus are known but none of the commonly grown dwarf varieties is resistant to all races. Work is being done to try and find suitable sources of resistance to anthracnose (and also to rust *(Uromyces appendiculatus* (Pers.) Unger) and halo blight *(Pseudomonas phaseolicola* (Burk.) Dowson) and to incorporate this resistance into suitable commercial varieties.

In the search for resistance, a large number of varieties and, in many cases, several lines of the same variety, have been tested in the glasshouse by inoculating seedlings with a spore suspension of *C. lindemuthianum.* During these tests, it was noticed that different lines of the same named variety and, in some cases, different plants within the one line sometimes reacted differently to inoculation with the same culture of the fungus.

Literature Review

Intravarietal variation in beans has been known for many years and has been used by growers and breeders in selecting out better strains of existing varieties. In the field of disease resistance, intravarietal variation has often been used to produce resistant lines from hitherto susceptible varieties. Barrus (1915) gives details of the selection of a single anthracnose-resistant plant, later named Wells Red Kidney, in a field of susceptible plants of the variety Red Kidney. In New South Wales, the variety Tweed Wonder arose as an anthracnose-resistant selection from Canadian Wonder (Anon. 1938) and more recently Wilson (unpublished data) selected out an anthracnose-resistant line from the susceptible variety Brown Beauty. This line is now widely grown under the name of Vickery strain Brown Beauty.

Waterhouse (1955) lists the results of inoculating a wide range of bean varieties with several isolates of *C. lindemuthianum.* He found the following varieties occurring as different strains giving distinct disease reactions —Burbank, Florida Belle, Kentucky Wonder, Red Valentine, Standard Pink, Staley's Surprise and The Wonder. For example, Red Valentine V58 is listed as resistant to all the isolates and Red Valentine B72 as susceptible.

Similar variation has been seen with other diseases. Pierce (1934) gives results of tests on nine strains of Great Northern U.I. These were all resistant to common mosaic whereas the original Great Northern from which they were selected was susceptible. Other workers such as Afanasiev and Morris (1952), Hungerford (1936, 1938), Johnson (1952), Murphy (1940) and others have noticed similar

variations in reaction to various virus diseases within bean varieties. Pugsley (1936) in a study of halo blight in Victoria, gives details of a strain of Canadian Wonder, known as Burnley Selection, resistant to halo blight and Isbell (1931) describes the development by selection of two varieties resistant to root knot nematode.

Materials and Methods

Ten seeds of each line to be tested were planted in 4-inch pots (five seeds per pot) in a glasshouse. When the primary leaves of the seedlings were expanding, the plants were sprayed with an aqueous suspension of spores of *C. lindemuthianum*. The plants were kept in a moist chamber for forty-eight hours after inoculation and then on the glasshouse bench. Results were read seven days after inoculation.

The inoculum was prepared by growing the fungus on pieces of autoclaved bean pod at 20°C for one week and washing off the pink spore mass with water when required. In all inoculations, the same culture (No. 80) provisionally determined as race AUST. 6 (Waterhouse 1955) was used. This race appears to be the most common one in N.S.W.

Detailed notes were kept of the number of seeds planted and the number of plants inoculated in each pot. This was essential due to the slow germination of some seeds and the possibility of their escaping infection. These plants could then be counted in error as resistant. In all cases where variation was found, a second test of the lines concerned was made.

Results

The results of the tests are given in Table 1. Of the fifteen varieties studied, six showed a distinct intravarietal variation in anthracnose reaction. The other nine varieties appeared to be quite homogeneous, all lines of any one variety being either completely resistant or completely susceptible. The six varieties in which variation was found were Canadian Wonder, Michelite, Red Kidney, Red Mexican, Startler Wax and Staley's Surprise.

An examination of Table 1 shows that two main types of variation occurred. These were:—

a. variation in reaction between two lots of seed of the same name from different sources, and
b. variation in reaction between individuals in the one sample of seed.

An example of the first type of variation is the variety Startler Wax and of the second the line W362 of Staley's Surprise.

In two cases, morphological differences were found between two lines of the same named variety. With Red Mexican, the susceptible line had brown seeds in contrast to the reddish colour of the resistant lines. In other characters, the lines seemed similar. In the case of Startler Wax, the resistant line (received from England under the name Mont d'Or) and one of the susceptible lines (W92) had purple hypocotyls in contrast to the green hypocotyls of the other lines. It has been pointed out by North and Squibbs (1952) that some lines of this variety have green and others purple hypocotyls. No other morphological differences between lines of the same variety were seen in this work.

Discussion

Variation in disease reaction within bean varieties is important to the plant pathologist for two main reasons. First, the identification of physiologic races of pathogens such as the anthracnose and rust fungi requires the use of standard sets of differential varieties over which isolates of the fungi are tested. Any variation in reaction noted in such tests is usually taken as a measure of variability in the pathogen. In view of the host variation noted above, the need for using pure lines of the particular differential varieties for all determinations of physiologic races is readily seen. Moreover, for results of different workers to be comparable, it is not enough to use seed of the same variety name; exactly the same pure line of seed should be used in each case.

Unless pure line differentials are used, one may be tending to study variation in the host as well as in the pathogen and unless the same pure line of seed is used by different

TABLE 1

Reaction of lines of various bean varieties to inoculation with a single isolate of *Colletotrichum lindemuthianum*.

Variety Name	Accession Number	Disease Reaction	Remarks
Canadian Wonder	W34	Segregating 15R:3S	Canadian Wonder is normally classed as susceptible to anthracnose in N.S.W.
	Five other lines	Resistant	
Contender	Two lines	Susceptible	
Gowards Special	Two lines	Susceptible	
Hawkesbury Wonder	Twelve lines	Susceptible	
Landreth Stingless	Eight lines	Susceptible	
Michelite	W28	Segregating 19R:1S	From Chile
	W87	Segregating 8R:4S	From U.S.A.
Plentiful	Three lines	Susceptible	
Red Kidney	W243	Resistant	From Victoria
	Four other lines	Susceptible	
Red Mexican	W246	Susceptible	From Victoria: brown seeds in contrast to reddish seeds of other lines.
	Five other lines	Resistant	All with reddish seeds.
Refugee U.S. No. 5	Five lines	Susceptible	
Richmond Wonder	Two lines	Susceptible	
Startler Wax	W393	Resistant	From England under the name Mont d'Or: purple hypocotyl.
	Five other lines	Susceptible	Four with green and one (W92) with purple hypocotyl.
Staleys Surprise	W38	Segregating 1R:9S	From N.S.W.
	W253	Segregating 15R:17S	From Victoria
	W362	Segregating 81R:86S	From N.S.W.
	One other line	Susceptible	
Streamliner	Two lines	Susceptible	
Tendergreen	Seven lines	Susceptible	

workers, the results they obtain cannot strictly be compared. This point has been stressed previously by Waterhouse (1955). Its importance in comparing races of a pathogen occurring in different areas is readily seen.

The second point is that this variation makes it possible to select out a resistant line from a variety hitherto thought to be susceptible to a particular disease. Many examples of this have been quoted above and, in the present work it has been done with the varieties Canadian Wonder and Staley's Surprise. With this latter variety, the resistant individuals selected out have been found in the few cases so far studied to breed true for resistance to the particular isolate of the fungus used.

Another point arising out of this work concerns the names of bean varieties. As

shown above, the name Staley's Surprise does not represent a genetically pure line but a mixture of closely related but genotypically different lines. This probably applies to most varieties and is the reason why workers wishing to compare results must not rely on the variety name but must use exactly the same pure line of seed in any tests they make.

The problem is complicated by the large number of names under which some varieties are known and by the use of the same name for varieties that are quite different. The presence of a small number of contaminating seeds of a different variety in a particular line of seed can also lead to confusion, especially if the contaminants are similar in colour, size and shape to the line being studied. Several cases of this have been noticed during the present work.

The origin of variation in disease reaction within bean varieties is not known. The mixing of breeding lines and the release of the bulk lines as a new variety, natural crossing and mutation are some of the possibilities (Bateman 1952). In the present work, the first of these probably played the major part in the variation observed but the influence of natural crossing in particular is in need of further study.

The possibility of intravarietal variation in disease reaction in the host is one that should not be overlooked in any plant disease work. Inoculation of series of plants is used in physiologic race determinations, in virus identifications and in other cases and, unless care is taken to exclude variation in the test plant material used by different workers, one is not sure whether the variable results obtained in different places represent differences in the pathogen or in the host series used. The need for building up standard pure lines of all plants used in test series is readily seen.

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Chemical Control of Eucalyptus Regrowth

In the Southern Tablelands Region of New South Wales it is common practice to clear areas of dry sclerophyll forest dominated by *Eucalyptus rossii* (Baker and Smith) for the establishment of plantations of *Pinus radiata*. Where the trees are not too large initial clearing may be done with a bulldozer, but whatever the method used, felled trees are often bulldozed into heaps for burning. Disturbance of the soil surface, with exposure of mineral soil, provides conditions suitable for the regeneration of Eucalypts from seed, but some regeneration from lignotubers of the original trees also occurs. The regrowth of the Eucalypts is especially important in firebreaks but may also be a problem in the plantation itself during the early establishment of pines.

Where it is desirable to establish a firebreak or power-line right-of-way within an otherwise undisturbed *E. rossii* community, the problem of regeneration may be even more serious because regular seed fall from the standing trees provides an annual crop of *Eucalyptus* seedlings. Any attempt to control such regrowth by means of a bulldozer simply accentuates the problem. The young trees readily break off at ground level, when many new shoots arise from the lignotuber, and again mineral soil is exposed, providing favourable conditions for the development of further seedlings.

A similar problem may occur in areas of dry sclerophyll forest that have been cleared to establish improved pastures, the development of which may be hampered by Eucalypt regrowth.

Methods adopted for the control of Eucalypt regrowth therefore should be such as to cause a minimum of soil disturbance and at the same time to preserve desirable plants which will prevent reinvasion by Eucalypts.

Easterbrook (1951) reported poor kills of *E. intermedia* and *E. maculata* sprayed with an aqueous suspension of the butoxyethanol esters of 2,4-D and 2,4,5-T, but up to 90 per cent. kill when these compounds were used with a kerosene carrier. Bissett and Shaw (1954) reported no differences among compounds of 2,4-D and 2,4,5-T applied to frilled trees or stumps of *E. teriticornis*.

Preliminary experiments with a number of weedicides indicated that the most promising

TABLE 1

Mean number of E. Rossii *per plot before and after application of chemicals in April, 1958.*

Treatment	Mean No. of trees at 10/4/58.	Mean No. of trees at 26/6/59.
Control	135	138
2.5 lb/ac 2,4,5-T	158	12
5.0 lb/ac 2,4,5-T	143	0.5
2.5 lb/ac 2,4,5-T + 2,4-D	143	10
5.0 lb/ac 2,4,5-T + 2,4-D	146	3
12.5 lb/ac Ammate	148	114
25 lb/ac Ammate	139	94
50 lb/ac Ammate	139	60
100 lb/ac Ammate	146	26
12.5 lb/ac Ammate + 0.5% wetting agent	160	65
25 lb/ac Ammate + 0.5% wetting agent	136	5
50 lb/ac Ammate + 0.5% wetting agent	156	4
100 lb/ac Ammate + 0.5% wetting agent	139	3

compound was the butoxyethanol ester of 2,4,5-T, either alone or in combination with the same ester of 2,4-D. Heavy applications of Ammate (ammonium sulphamate) were also effective. The experiments described below were designed to make further tests of these substances, and in particular to determine the importance of wetting agents on the effectiveness of Ammate as a foliage spray at relatively low concentrations.

Methods

The experiments were located mid-way between Queanbeyan and Captain's Flat in New South Wales, on an area which had been bulldozed two years previously. The regrowth consisted of *E. rossii* 1½ to 2 ft high. Plots were 100 x 20 links (1/50 acre) and treatments were replicated 4 times, in a randomized block design.

The chemicals used were the butoxyethanol ester of 2,4,5-T; a mixture of the butoxyethanol esters of 2,4-D and 2,4,5-T in the proportion 2 : 1; and Ammate with and without a commercial liquid detergent (Comprox.—A C.O.R. product). All were applied in aqueous solution or emulsion as foliage sprays at a rate equivalent to 100 gal per acre, using a two-gallon pneumatic hand spray operating at a pressure of 30 lb per square inch. Sprays were applied on April 10, 1958 and June 26, 1958.

Counts of living trees on each plot were made prior to treatment, and again on June 25, 1959—an interval of 14 months for the April treatment and 12 months for the June treatment.

Results

The results are given in Tables 1 and 2. Spraying in April reduced the population of Eucalypts to low levels, while June spraying was ineffective. The most successful chemicals were the mixed esters, and 2,4,5-T alone especially at the higher rates of application, and Ammate when used in conjunction with a wetting agent.

Discussion

It seems clear that the effectiveness of the treatments in reducing regrowth of *E. rossii* is, in part at least, dependent on the time of the year at which the trees are sprayed. The June spraying was not a success. Only one treatment, Ammate at the heaviest rate, gave any appreciable reduction.

TABLE 2

Mean number of E. Rossii *per plot before and after application of weedicides in June, 1958.*

Treatment Ammate (lb/ac)	Wetting Agent	Mean no. of trees 26/6/58	Mean no. of trees 25/6/59
Nil	Nil	90	82
6.25	Nil	108	90
12.5	Nil	85	75
25	Nil	100	90
50	Nil	104	94
100	Nil	92	64
6.25	0.05%	87	77
12.5	0.05%	99	86
25	0.05%	102	81
50	0.05%	91	62
100	0.05%	96	70
6.25	0.1%	87	68
12.5	0.1%	95	78
25	0.1%	100	88
50	0.1%	95	71
100	0.1%	94	63
6.25	0.5%	97	85
12.5	0.5%	96	86
25	0.5%	105	83
50	0.5%	108	69
100	0.5%	93	19

Spraying in April was effective in reducing plant numbers. The most striking feature of the result at this time of application was the pronounced increase in the effectiveness of Ammate obtained by the addition of relatively low amounts of wetting agent.

April spraying with 2,4,5-T and with mixed esters, especially at the higher rate of 5 lb per acre, was also effective in reducing plant numbers. These results are of interest in relation to the findings of Easterbrook (1951).

Apart from its value in increasing the effectiveness of Ammate, the use of a wetting agent with this compound has the further advantage of making field operations easier. Sprayed foliage appears glossy for 5-10

minutes, hence the operator can readily determine whether the leaves have been adequately covered with spray. In the absence of the wetting agent it is difficult to determine whether leaves have been sprayed and this may lead to wastage through excessive run-off.

Further investigations are required to determine the most economic rates of application, especially of Ammate, and also the minimum effective concentration of wetting agent. It is also necessary to determine more accurately the full period during which applications are effective. Little data on the conditions influencing the effectiveness of the sprays is available, but it seems likely that both temperature and soil moisture may be involved.

Though spray treatment may very markedly reduce plant numbers, it should be pointed out that at 3 plants per plot of 1/50 acre, there are still 150 trees per acre, which for most purposes would be excessive. It is therefore probable that a second treatment of the surviving trees on the area would be required. In some circumstances, e.g., firebreaks and power line right-of-way, 100 per cent. kill may be required, but where it is proposed to establish improved pasture it is desirable to retain a few trees, partly to provide shelter for grazing stock and partly to provide effective competition for future generations of seedlings and so prevent reinvasion.

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The Effect of Stem Infestation of Tobacco with *Peronospora tabacina* Adam. on Foliage Reaction to Blue Mold

In Australia seed bed infection of tobacco with blue-mould (*Peronospora tabacina* Adam.) results in a percentage of the surviving plants becoming stem infected (Angell 1959). Field observations (Pont 1957) suggested that stem infected plants which do not show severe stem-break symptoms, are frequently freer of foliage symptoms of blue-mould than non stem-infected neighbouring plants.

Pont's field observation was tested experimentally under glasshouse conditions using an injection technique (Cruickshank and Palmer 1954). Plants of similar age and size were grown in six inch pots. They were split into two groups of four plants each. The third

Figure 1 — Relationship between time of stem injection and leaf sporulation intensity.

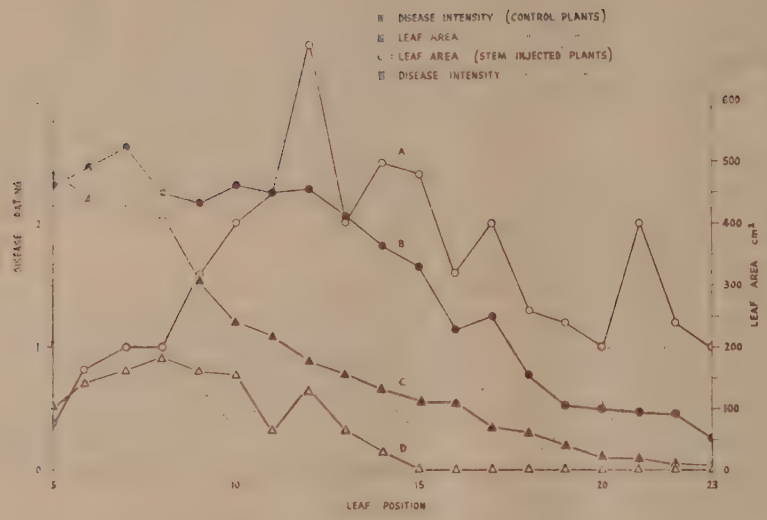

Figure 2 — Effect of stem injection on leaf and disease development.

leaf from the base of each plant was cut off to within an inch of the stem and 0.5 ml of a conidial suspension of *P. tabacina* was injected into the cut petioles of one group. The control group was injected with sterile water. The plants were left for four weeks and then the foliage was aerially inoculated with a spore suspension of the same fungus under conditions favourable for leaf infection (Cruickshank 1958). Leaf discs were cut from both plant groups eight days later, and incubated overnight under optimal conditions (Cruickshank 1958) to determine the sporulation response.

No sporulation occurred on discs cut from stem injected plants, although normal sporulation occurred on the control plant leaf-discs. Typical mild stem infection resulted from stem injection (Mandryk 1960).

Further glasshouse experiments were carried out to determine (a) the relationship between time of stem injection and sporulation response; (b) the effect of stem injection on leaf size and occurrence of disease in leaves.

Plants used in these experiments were approximately 25-30 cm in height at the time of stem injection. In the first experiment two groups of similar plants were injected with spore suspension and water respectively. Lots of five plants from each group were foliage inoculated after 0, 14, 28 and 56 days and leaf-discs were cut eight days later for the sporulation response test. The results, plotted in terms of percentage of control, are given in Figure 1. It appears that although the full effect of stem injection on foliage development of *P. tabacina* is not evident until 28 days after injection, there is an anti-sporulation effect after 14 days, resulting in a 68 per cent. reduction in sporulation intensity.

In the second experiment 72 tobacco plants (36 treated + 36 control) were foliage inoculated 21 days after stem injection and subsequently examined at the flowering stage for leaf size and infected leaf area. The area of necrotic and chlorotic spots was assessed on a scale rating from 0-4.

The six lower leaves from stem-injected plants did not differ significantly in size or in incidence of disease from similar leaves of control plants. These leaves were almost three-quarters of their full size at the time of stem injection and were not affected by it. Beginning with the seventh leaf and continuing to the top of the plant there was a strong association between the size of leaf at the time of stem injection and its subsequent growth and reaction to the disease. Thus leaf nine, which at the time of injection was 2 cm in length and 1 cm in

width, was more affected than leaf seven, which was 15 cm in length and 6 cm in width. Leaves 10 to 23 which developed subsequent to stem injection, were almost 40 per cent. smaller than similar leaves from healthy plants (Figure 2). Leaves from stem injected plants were wrinkled at the margin and their yellowish colour indicated premature senescene. The injected plants matured and flowered two weeks earlier than the controls.

Stem symptoms in the injected plants were typical of mild infection (Mandryk 1960). Foliage symptoms were markedly reduced in extent and severity compared with the control plants (Figure 2). Thirty-eight per cent. of the leaves on the injected plants remained apparently healthy.

Field Experiments

A trial was conducted to determine the effect of stem injection on blue-mould development on leaves of plants of different age groups under field conditions. A split plot randomised block design was split on stem injection versus control with the same time of foliage inoculation. Four dates of stem injection were used spaced at 32, 44, 54 and 60 days after transplanting. Seven days after the final stem injection treatment the complete trial was foliage inoculated. The latter combined with a low level of natural infection which occurred at about this time provided a moderate level of foliage infection. Individual plants were scored on a 0-4 basis (0-disease free, 4-maximum level of infection in the trial) two weeks later. Six replications of 18 plants were grown but only every second plant was scored. The results in terms of plant infection ratings were calculated by dividing the total plant score per replicate by the number of plants within each replicate. Plants injected 32 days after transplanting were severely dwarfed and lodged. They exhibited symptoms characteristic of severely stem infected plants and emphasized the known economic importance of severe stem infection under field conditions. The results of the subsequent treatments are presented in Figure 3. An analysis of the latter results in terms of difference of ratings of treated from the corresponding control plots indicated that injection at 44 days and 53 days after transplanting significantly

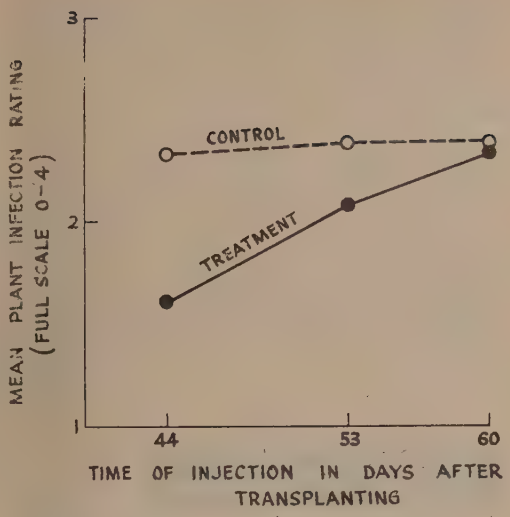

Figure 3 — Relationship between time of stem injection and disease severity in field experiment.

($P < 0.01$, and $P < 0.05$ respectively) reduced foliage infection.

Discussion

The results in all experiments confirm the field observation that change in foliage reaction to blue-mould occurs in stem infected plants. The phenomenon is a dynamic one in that plant age at the time of injection, and the time interval between stem injection and foliage inoculation are important in terms of the final host reaction. Associated and yet not necessarily directly connected with the change in disease reaction is a change in growth habit.

The mechanism behind the two phenomena described is at present unknown. The changes in growth habit may be directly due to the effect of the pathogen on the general metabolism of the plant. The change in disease reaction of the leaves may be due to the formation of a translocatable antifungal toxin at the site of stem infection. Alternatively, it may be associated with nutritional changes occurring concurrently with the change in growth habit and the prematurely induced senescence of the plant.

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Thesis Summary

Cytogenetical Studies of Wheat in Relation to Monosomic Analysis and Disease Resistance Derived from *Agropyron elongatum*

By means of monosomic analysis the following genes for resistance to race 126 Anz. 1 of stem rust of wheat were located on specific chromosomes. The single dominant gene *Sr* 6 of Eureka W.1325 was located on chromosome XX. The single dominant gene *Sr* 9 of Kenya W.744 was located on chromosome X111. The two linked dominant complementary genes *Sr* 11 and *Sr* 12 of both Gabo W.1422 and Yalta W.1373 were located on chromosome X.

The presence of a ligule was found to be due to two independent duplicate dominant genes located on homeologous chromosomes 11 and XX. The fact that these two chromosomes are homeologous is of probable evolutionary significance.

From the cytogenetical examination of plants in lines segregating for wheat stem rust resistance derived from *Agropyron elongatum,* it was found that resistance depended upon the presence of an extra chromosome derived from *Agropyron.* When this added univalent was transmitted through both gametes the resultant plants (2n = 44) bred true for resistance.

The zygotic and female transmission rates of this univalent was determined to be 36.3 per cent. and 26.7 per cent. respectively. Thus the transmission rate from the male side was calculated to be 13.2 per cent.

Except for rare instances resistance to stem rust was correlated with resistance to leaf rust. Plants exhibiting non-correlation were found to possess a monotelochromosome or a bivalent consisting of a pair of telochromosomes, indicating that the genes for resistance to these two types of rust are located on opposite arms of the same *Agropyron* chromosome.

In order to eliminate undesirable genetic material present on the added chromosomes X-radiation experiments involving 44 chromosome plants have been initiated with the aim of inducing translocation of the genes for resistance into wheat chromosomes.

It is anticipated that this transfer may also be induced by crossing the monosomic lines with the 44 chromosome type. Seventy-five per cent. of the F_1 plants will contain 20 wheat bivalents plus one *Agropyron* univalent and one wheat univalent. Under these conditions these two chromosomes may undergo synapsis and crossing over, as there is provided maximum opportunity for the pairing of non-homologous chromosomes.

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Book Review

Agricultural Credit in Economically Underdeveloped Countries

By Dr. Horace Belshaw

F.A.O. Publication, 1959. 255 *pages. Price* 15*s.* (*Sterling*).

The book is written by a Professor of Economics in Victoria University of Wellington, New Zealand, and is most useful for anybody who is interested in the functioning of banks and co-operatives from the point of view of agricultural credit. Although the title of the book refers to underdeveloped countries, much of the factual data, as well as the discussions on the various topics, have a general application. It is equally valuable to those with and without training in either banking or co-operatives, though the parts dealing with banking are more self-contained for the uninitiated. The book is completely free from economic jargon.

Investment in agirculture *versus* investment in industry is discussed for a start. Increased income from agriculture is the aim but national prestige may favour expenditure on industry even when the return from simple capital investment in agriculture (e.g., fertilizers) would be great. It is worth mentioning that in Australia the legislation prescribes for the Commonwealth Banking Corporation Board to have a banking policy ". . . to the greatest advantage of the people of Australia and have due regard to the stability and balanced development of the Australian economy."

Dr. Belshaw points out that under-employment with the existing method of labour utilisation, or with the introduction of new production methods could be overcome, among other things, by the diversion of surplus labour to supplementary occupations or by the introduction of improved farming methods. Both would require additional caiptal investment, particularly when temporary reduction of cash cropping is involved; this is known only too well in many eroded farming areas in Australia.

The aim ought to be to use credit for a cumulative increase in output and not merely for maintaining existing production and consumption levels. It is equally important to put savings to productive use and reduce large spending on personal items such as weddings, which in some countries may amount to a full year's income of all but the richest.

Lack of an adequate number of banking offices leaves the provision of credit in the hands of money lenders and friends and relatives of the borrower. The list of questionable practices among money lenders in India reads almost like fiction. In the list of countries selected for illustrating differences in the number of bank branches per million of population, Australia is not included, if it were, it would head the list.

The various methods used for the promotion of rural savings are described and illustrated by examples from many countries. The transfer of funds, both public and private, into agriculture, as alternative means for increasing the supply of funds, is also covered. Apart from the degree of risk and liquidity, the rate of reward and alternative ways of investment will be the primary considerations of the private investor.

The general desiderata for loans are clearly stated. The section dealing with Expenses Related to Credit suggests that costs of the agricultural extension provided by the credit institution should not be charged against the borrower any more than the cost of the extension services provided by the Department of Agriculture. Attention is drawn to the close relationship between productive and non-productive credit and the emphasis is put on repayment capacity rather than credit worthiness. These views are in line with the policy of the Commonwealth Development Bank in Australia.

Various aspects of organisation of credit are discussed in great detail. It is claimed that commercial banks are not suited for the provision of credit in a peasant type of agriculture. In India only 2.7 per cent. of the advances of commercial banks for the agricultural production (while in Australia it is about a quarter of the total advances) and these banks play only a relatively small part in the provision of loans for co-operative credit institutions. The conclusion is drawn that decentralisation can be achieved either through the establishment of rural banks under the central institution, assisted and supervised by it, or as an alternative, committtees or boards made up of local responsible people and empowered to issue loans of liimted amounts.

Co-operative credit is approached by Dr. Belshaw with a discussion of the organisation of various types

of co-operatives and quasi-co-operative credit institutions. Problems arising from short term funds and unlimited liability are discussed and illustrated. It is claimed that in large countries a federal system is preferred for the provision of long-term co-operative credit and that loans for productive purposes ought to be given preference over those for debt redemption. The conclusion is drawn that short-term credit for up to about five years is more likely to be successful because for this funds could be provided from within societies.

The sections dealing with Supervised Credit and The Functions of Central Banks are more fitted for appendices than for finishing the book, considering that they cover a number of aspects previously discussed at some length. Since the author's conclusions are usually given at the points where the various topics are discussed, the final section headed Conclusions is a misnomer. It is rather a re-statement of the problems in a summarised form.

The literature cited is quite formidable, but in the course of the discussions throughout the book the overwhelming majority of the examples is based on the All-India Rural Credit Survey of 1955, carried out by the Reserve Bank of India. English, French. Spanish and German lists of literature are given for further reading.

I. MOLNAR.

Sheep Management and Diseases

By H. G. Belschner

Angus and Robertson Ltd., Sydney. 6th Edition. 1960.

There have been many important advances in the knowledge on sheep and wool production, particularly in Australia, since the book on "Sheep Management and Diseases," by H. G. Belschner, was first published in 1950.

The new edition, published in 1960 by Angus and Robertson Ltd., has been completely revised, enlarged and reset, in a manner which reflects great credit on both the author and the publishers.

In revising the old text, Dr. Belschner shows ample evidence that he has referred to many recent scientific publications in the fields of nutrition, breeding, reproduction, disease control and management. However he has retained the well tried formula of combining a brief review of old and new information with practical recommendations which are based on a wise combination of scientific knowledge and practical experience.

Part I of the book deals with aspects of sheep husbandry, breeding, wool, reproduction, breeds, improvements and general property management. New information of particular interest is included in the sections dealing with sheep breeding, blowfly control and drought feeding. The section on sheep breeding for example has been reviewed in the light of important results from recent experiments on the selection of Merino sheep which have been carried out by the New South Wales Department of Agriculture and the C.S.I.R.O.

Part II of the book includes adequate summaries on the diagnosis and control of all the common and many uncommon diseases of sheep in Australia. Throughout the whole book Dr. Belschner emphasises many aspects of the relation between management and disease control.

A pleasing feature is the excellent choice of photographs and diagrams, which are in keeping with the revised text. Most sections also have an adequate list of recent references.

There is no doubt that this authentic and well written book will continue it's important role as a much used reference in the many spheres of interest in the sheep industry such as the Agricultural Colleges, University Agriculture and Veterinary faculties, Veterinary Practitioners and Technical Advisory Services. It will also be used by the increasing number of sheep farmers who have sufficient technical training to feel the need for a detailed and up to date reference which will guide them in the practical application of scientific principles to the task of improving sheep and wool production.

P. G. HYLAND.

Talks

Progress in Farm Mechanization in Britain

Mr. Herbert Fail, Head of the Department of Agricultural Engineering, University of Durham, in an address to the South Aust. Branch.

Background to British Agriculture

The land is mainly undulating or hilly, except for the Black Fen country which is first-class arable land producing crops of grain, potatoes and sugar beet well above the national average. The land is generally well watered with rivers and streams.

The presence of trees in hedges, the pylons and cables of the electricity grid system, and the small size of fields, make the use of aircraft in agriculture rare.

Soils range from stiff intractable clays, with a ploughing resistance of some 13 lb per sq. in. of furrow section equivalent to 7 Db. hp. per furrow, to sands of only 4 lb per sq. in. ploughing resistance equivalent to 3-4 Db. hp. per furrow. Clay soils of over 13 lb per sq. in. ploughing resistance are usually put down to grass.

In between the above types is a range of loams, and chalk and limestone soils, plus a small area of black fen. Many of the soils are stony and rocky, but the equipment is designed accordingly.

The rainfall varies from 21 inches per annum on the eastern side to 48 inches on the western side, with 80 inches in the mountains. Hence in most seasons there is little need for irrigation, but fruit growers have found sprinkler irrigation useful in preventing frost damage to trees when the blossom is setting. The film of ice on the setting blossom prevents damage even if the temperature goes well below freezing point.

As the rainfall has no regular pattern, it is not possible to avoid wet periods during harvests, so that new haymaking techniques such as tripoding and in-barn haydrying have been developed in order to obtain good quality hay. Often relative humidities are 85-90 per cent. at harvest, and grain dryers are used to reduce moisture content to prevent grain from heating and going mouldy when stored.

The proportion of mixed farms is high but there are many dairy farms on the suitable soils, and grass farms in the hillier districts mainly devoted to stock rearing.

Of a total of 361,000 farms, only 25 per cent. are over 100 acres, but they cover 17 million of the 24½ million acres of arable and grassland and are the most important contributors to Britain's food production. Only 590 farms are over 1,000 acres.

There are 24½ million acres of arable and grass, plus 5 million acres of rough grazings—poor hilly grassland with unpalatable species with a very short growing season, often over-run with bracken. With the population of over 50 million, it is necessary not only to increase farming efficiency on better soils, but also to improve the rough-grazings, and I have developed sod-seeding equipment for the latter purpose.

Three thousand acres per annum of good farmland is being used by housing estates, schools and playing fields, new motorways, open cut coal, etc.

The number of regular workers in agriculture is also decreasing. In the last five years it has gone from 550,000 to 500,000.

The basic wage for regular workers in the United Kingdom is only £8 per week compared to £14 in Australia, but wages are the biggest farming expense comprising 28 per cent. of the total. Machinery is only 18 per cent. of the total.

The Oxford estimate shows that since the War food production was increased by 50 per cent. and it is estimated that output per man has gone up by 20 per cent. The increase in food production is not due solely to mechanisation, but the higher output per man could not have been achieved without it.

Some examples of labour saving

In an 8 hour day, a man with 2 horses and a single-furrow plough could plough 1 acre. The labour cost alone at the present rate is 32/- per day, whereas 1 man, with 1 tractor and a 3-furrow plough can plough 6 acres a day with a total cost of less than £1 per acre.

Loading and spreading manure by hand-fork takes 50 man-minutes per ton. With the tractor, front-end loader and a manure spreader, the time is 10 man-minutes per ton, and the manure is spread more finely for ploughing in.

Planting potatoes by hand takes 18 man-hours per acre, but with a £35, 2-row planting attachment on the ridger, the man-hours are reduced to 9 per acre. A 2-row automatic planter reduces the man hours per acre to only 6, and both mechanical methods give more accurate spacing than hand planting.

Combining and drying grain takes 9 man-hours per ton, while binding, stooking, stacking and threshing takes 28 man-hours, with a much higher loss of grain.

In all cases, except in making high quality hay, mechanisation reduces the labour requirement. The

pick-up baling method, with the greatest risk of weather damage, takes 5 man-hours per ton, the tripod method, which gets the hay off the ground while it is still tough and green, takes 15 man-hours; the in-barn haydrying method takes 16 man-hours per ton. Lucerne-hay made with the pick-up baler gave a product with 8 per cent. crude protein, with the tripod 12 per cent. and the in-barn dryer 14 per cent.

Tractor numbers in the United Kingdom have gone from 46,000 in 1939 to 400,000 today. There is 1 tractor to every 66 acres of arable and grassland, and the tractors have greatly improved in their power, efficiency and adaptability. Practically every tractor sold to British Farmers is Diesel engined, and the vast majority have pneumatic tyres. Four-wheel drive tractors are being used now in Britain, but the extra cost is high in spite of the increase of some 60 per cent. in pull.

The National Institute of Agricultural Engineering in Bedfordshire has produced a tractor with hydrostatic transmission in which the clutch, gear box, differential and back axle are replaced by a variable output hydraulic pump connected by flexible piping to a hydraulic motor in each rear wheel. The pump is driven by the normal Diesel engine, and the speed range of the tractor from full speed forward to full speed reverse is obtained smoothly and steplessly by moving a small control lever. The omission of the usual transmission system permits the tractor to be designed with equipment positioned most efficiently. Furthermore, four-wheel drive is greatly simplified.

The mouldboard plough is still used because of its ability to bury weeds completely—an essential in Britain's moist climate. There are now several makes of mounted reversible ploughs, turned over hydraulically, which enable fields to be ploughed with a level surface from one side to the other—a requirement for mechanising certain crops.

The rotary cultivator, popular in market-gardens, has become increasingly popular in the tractor-mounted models for farmwork. The L-blade type invented in Australia is the best equipment for seed-bed preparation under difficult conditions, reclamation of poor land, eradication of couch (*Agropyron* and *Agrostis* species), the worst arable land weed; and eradication of bracken (*Pteridium aquilinum*), the worst grassland weed.

In silage making, the labour requirement has been reduced, first by the simple buck-rake on the back of the tractor, and, later, by the flail harvester. Self-feeding of silage is becoming popular; a framework is placed across the end of the silage clamp where the stock feed.

How has our progress been achieved?

Many factors have contributed:

1. *Government help* in income tax allowances on the purchase of new equipment plus a reduction for wear and tear allowance on the written-down value each year, has enabled the larger farmers to keep their equipment up-to-date. The smaller farmers can purchase the still efficient replaced equipment at a reasonable figure.

There are also various farm subsidies and grants aimed at increasing efficiency.

2. *Research.* Great Britain has two research stations, the National Institute of Agricultural Engineering and the Scottish Machinery Testing Station for testing, improving and developing equipment.

3. *Advisory.* In the National Agricultural Advisory Service there is a specialist farm mechanisation adviser in each county, and a senior specialist adviser in each regional headquarters. The head of the machinery advisory department has his headquarters at the National Institute of Agricultural Engineering. The N.A.A.S. also holds many large scale demonstrations of equipment and techniques.

4. *Education.* There is a post-graduate course for the M.Sc. in Agricultural Engineering at the University of Durham, for graduates in Agriculture or Engineering. The Agricultural graduates are taught engineering subjects and the Engineering graduates agricultural subjects. All candidates study equipment and advanced farm mechanisation, economics, soil physics, and complete a thesis on a research project. About one-third of the holders of this degree have gone into industry, one-third into research and advisory work and the remainder are teaching at universities or colleges.

Farm machinery is included in courses for Agricultural degrees at Universities, and in courses at Agricultural Colleges and Farm Institutes.

There is a 2-year National Diploma in Agricultural Engineering run by the Institute of Agricultural Engineers of Britain, and large tractor firms run short courses on agricultural equipment.

Californian Grape Production an Example of Modern Specialized Agriculture

Dr. B. G. Coombe, Lecturer in Plant Physiology (Horticulture), Waite Institute, in an address to the South Australian Branch.

It is worthwhile for Australian agriculturists to give thought to extensive specialization of farms. This trend is strong in the U.S.A., especially California,

and there are symptoms of the same tendency in Australia. Compared with mixed, family farms, this type of Agriculture has different objectives. Shultis (1951) describes farming in California as "an intensive, specialised, commercial undertaking conducted to make money in return for labour, managerial ability and capital invested."

What are the trends in these farms?

1. Specialisation. Each farm grows fewer commodities, e.g. one property of 1,000 acres near Fresus grows mainly table grapes and, incidentally, employs three Ph.D's to look after its technical problems.
2. Farms tend to become fewer and larger and income per acre tends to increase.
3. Mechanization per farm increases. Machines take over hand operations, Their high initial cost is spread over large numbers of production units so that cost per unit is low. The net effect has lowered cost of production.

It costs a lot of money to begin spinning the wheel of specialization, and then, once it has begun, there is a snow-balling effect which tends to increase the wheel's momentum. The mass production methods used in industry are analogous.

California has tremendous natural wealth which has meant that money has been available to spend on farms. Her plentiful water supply, fertile soils and reliable Mediterranean climate have permitted the production of a wide variety of commodities with high yields of good quality. California has at her command large markets for her produce — the home market alone is considerable. Furthermore there are excellent transport facilities, especially for perishable goods. But one of the most important factors contributing to the extent of specialization is the nature of the farmers; they are progressive, venturesome and competitive; they regard their farms as businesses and themselves as businessmen, not only labourers; they endeavour to increase demand by reducing costs; they are dedicated to serve the customer, provided the customer pays.

Australia's poverty in primary resources has delayed the spinning of the wheel of specialization even though the desire may have been there to start it. There is a greater emphasis on mixed, family farms in Australia; the Government soldier settlement policy has supported this tendency. The Australian farmer places less emphasis on the personal characteristics mentioned above as being needed for specialization. Finally Australian farms are generally poorer. This is due to poorer natural resources and to poorer management. In many cases farmers' hands are tied by lack of capital to change things but there is also the question of his incomplete understanding of technical and managerial problems. He needs a lot of help, but, because he is not specialized, it is very much harder for help to be given.

A great virtue of specialization is the way it facilitates extension and applied research. California has the added advantage in that all research and extension bodies are under one roof, the University of California. The difference in effectiveness is shown dramatically when one compares the meagre efforts in Australian viticultural research and extension compared with those in California. This is not due to a difference in numbers of workers because there are nearly as many technical people per acre of grapes in Australia as in California. Australian efforts are dissipated by geographical and organizational scatter.

Grapes are the seventh most valuable crop grown in California bringing in 120 million dollars annually. The raisin industry is huge and produces 40 per cent of world production. California is also the leading producer of table grapes — 25 per cent of world production. The wine industry ranks eight in the world. Yields are very high — 6 tons per acre compared with 4 in Australia and 2 for the world.

Reference: Shultis, A (1951) Farming in California. Calif. Ag. Exp. Stn. Circ. 173.

The Diversity of *Phaseolus Vulgaris*

By H. M. Groszmann in an address to the Queensland Branch.

Phaseolus vulgaris here represented by French and navy beans, originated in tropical America where it has been cultivated for some thousands of years for the mature seed. After the Spanish conquest of Peru and Mexico it was taken to Europe. In addition to further types of seed beans, there evolved in Europe flesh-podded string and stringless varieties. Subsequently in the United States of America types were developed with very little fibre in the pod walls.

Beans exhibit a wide range of variation in growth habit, pod size, colour and texture, seed size and colour, flower colour, resistance to disease, and adaption to different growing conditions. Numerous genes which might otherwise have been lost, such as those affecting pod and seed types, have no doubt been conserved by human agency; occasional crosses have permitted a wide range of combinations which have been fixed by the high degree of self-pollination normal to the species.

Believing that the demand for stringless beans will increase, we are endeavouring to breed productive stringless varieties for Queensland conditions. However, both our own standard string varieties and the American stringless ones which are our main parental types have been developed mainly for temperate summers. In Queensland beans are not grown under these conditions but from the sub-tropics to the tropics, and, in places, right throughout the year. In an attempt to obtain greater adaptation to some of our conditions, we have introduced a wide range of ecotypes from tropical and sub-tropical America. These and other varieties are being screened to determine broadly what conditions beans prefer, what stress conditions seriously affect them, and to what extent some varieties excel others in their tolerance of these stresses. Already considerable differences have been noted in reaction to cold winds, and sunburning, in pod setting under high and low temperatures, and in etiolation under certain light regimes.

While variation between varieties is obvious, considerable diversity exists within commercial varieties and plays a useful part in increasing their adaptability.

Environments in Queensland differ so much that it is believed that the best use of the available variation can be made by breeding for each of the major growing conditions.

At the same time the variation in the weather in any one season can make such demands on adaptability, that once the minimum requirements of the industry for uniformity have been satisfied, it seems desirable to retain in a variety the maximum physiological diversity.

Four Nematode Problems

By R. C. Colbran in an address to the Queensland Branch.

Although the beet nematode *Heterodera schachtii* Schmidt has been known as a pest in New South Wales and Victoria for many years it was not found in Queensland until May, 1960. Cabbage plants from Gatton College were submitted for examination because the overall growth was unsatisfactory and many had failed to head. The root system was characterized by a shortage of primary roots and an abundance of short feeder roots covered with the white cysts of this nematode. A soil examination revealed the presence of large numbers of brown cysts.

Heterodera schachtii is very difficult to control with the nematocides at present available and control is best achieved by the use of crop rotation. Host plants include cauliflowers, brussels sprouts, broccoli, turnips, rhubarb and beetroot. It is not advisable to grow potatoes and carrots in infested soil as there is every likelihood of spreading cysts in soil adhering to the marketed produce.

A new species of sheath nematode *Hemicycliophora sp.* producing small terminal galls on the roots of citrus was found at Burrum. The only other record of a sheath nematode causing this type of injury on citrus is that of *Hemicycliophora arenaria* from California. Sheath nematodes are ectoparasites common in sandy soils. This is the second native species of *Hemicycliophora* found to attack a cultivated crop in Queensland and suggests that other species found in virgin areas will eventually become of economic significance.

Root-rot of bananas due to the burrowing nematode *Radopholus similis* (Cobb) is widespread in Queensland and New South Wales. It has been spread by the use of infested planting material. A number of growers carry out routine treatment of planting material with hot water at 55°C for 15-20 minutes. Soil fumigation in banana plantations is frequently impracticable because of the terrain.

The failure of stands of white clover is often caused by heavy infestations of root-knot nematodes. In the U.S.A. a number of nematode-resistant lines have been selected and selection and breeding may offer a solution to the problem. Apart from root-knot nematodes, decline of clover stands in Queensland has been associated with infestations of root-lesion and cyst-forming nematodes.

The Control of Insects with Radio active Substances

By Dr. P. B. Cornwell, Entomology Group, Isotopic Research Division, U.K. Atomic Energy Authority, in an address to the South Australian Branch.

There are two approaches to the problem:—
1. Direct control by irradiation to kill the insects.
2. Indirect control by releasing adult male insects which have been irradiated as larvae to make them sterile.

The direct control method has been used to control insect pests of wheat and other grain in large silos.

This method has the advantage that it is foolproof and can give 100 per cent. control. With big silos, costs are comparable with those of Phostoxin fumigation.

Another application of this method of control is the irradiation of imported bales of goat hair to kill disease organisms such as anthrax. The anthrax organism has an extremely resistant spore which is hard to kill by conventional methods. The bales of goat hair are fed into a large chamber containing a source of radioactivity. With the level of radioactivity lethal to man, the room and its source of radiation must be completely shielded. The treated fibres are in no way dangerous to man. This plant, situated in Melbourne, is the first of its type in the world.

The indirect method, in which adult males which have been made sterile by irradiation at the larval stage are released, has been used with success in controlling the screw-worm fly in Florida and Curacao. This fly causes huge losses in cattle each year in many parts of America. Millions of irradiated, sterile, male flies were released in Curacao. These sterile flies mated, but as the female mates only once, no fertile eggs resulted. In a very short time Curacao was free of the pest.

The technique was again applied, successfully, in Florida where the fly was eliminated from 50,000 square miles. This technique is now being considered in Australia for the elimination of the fruit fly. However, control by this method requires much man power and money. The elimination of screw-worm fly from Florida needed the following resources: a staff of three hundred, 20 aeroplanes to spread the irradiated male flies, and several hundred thousand pounds of meat, blood, and honey on which the fly maggots were bred.

The following conditions must be considered in controlling an insect pest by the release of sterile males.

1. The population of the insects in the field must be relatively low.

2. The mating habits must be suitable — preferably there should only be one mating as with the screw-worm fly.

3. The area infected must be isolated, to prevent re-infection after treatment.

4. The insect should be easily handled.

5. The adults must be fairly mobile.

6. Sterilization by irradiation is needed without loss of vigour and longevity in the adult.

More Production through Better Advice

During May, June, and July, 1960, the A.C.T. Branch held a series of four meetings at which the theme was more production through better advice. The objective was to present information on less well-known aspects of agricultural extension work.

The Role of the Farm Management Specialist

By A. H. Rowe, Bureau of Agricultural Economics.

Agricultural extension has remained the Cinderella of our agricultural education services, despite Australia's dependence on agriculture for a quarter of its national and three quarters of its export income. Salaries and status of extension personnel in Australia contrast startlingly with those in the United Kingdom whose agriculture contributes a mere 4 per cent to the national income. An important reason for this disparity is the greatly increased effectiveness of N.A.A.S.'s work through in-service training of officers in farm management priniciples and encouragement from the top to give farm management advice.

It is suggested that there are five major reasons why Institute members are becoming increasingly concerned with better (more profitable) advice to farmers:

1. Viewed nationally, Australia's rapidly developing economy makes heavy and increasing demands on imports, most of which must be paid for by export earnings. Continued expansion, therefore, depends on an efficient agriculture providing an increased output at an acceptable quality and price to retain old and develop new markets. From a national viewpoint, then, farm management advisory work can help farmers make most profitable use of scarce resources consistent with good husbandry and land conservation.

2. Scientists have become more aware of the need to marry technical and economical advice together if their research results are to be more widely applied. Most agricultural scientists realise that technical innovation in itself is of little value unless it can be profitably integrated on individual farms. Farm management advice can play an important role in tailoring scientific knowledge to the individual

farmers' resources and abilities to improve net farm income.

3. In other countries, experience has shown that advisory services rely, in their formative years, on the technical approach. The adviser merely passes on results of research station trials, or diagnoses and prescribes for pests and diseases of crops. This means he is concerned with the practical issues confronting the farmer as a husbandman, not as a manager in the economic sense. This approach is understandable, even justified, in the light of the lag between what is technically possible and what is actually practised on farms. The next essential step is farm management advice.

4. Farmers themselves are becoming more management-conscious. Modern farming is no longer a way of life but a way of making a living. The ever-growing capital requirements of modern agriculture have necessitated closer attention by the farmer to the economic results of his managerial decisions. The consequences of bad and ill-informed decisions have become much more serious and can rapidly lead to bankruptcy. Establishment of farm management clubs, the interest in the Bureau's Continuous Farm Studies, and increasing requests to extension officers for economic advice on whole farm management problems, are indications of this trend.

5. The profession of agricultural economics has developed rapidly throughout Australia during the past decade. Interest in the results and individual application of farm management research has been stimulated by the published work of agricultural economists working in University faculties, State Departments of Agriculture and the Bureau.

Definition

Farm Management means many things to many people. To the economist, it refers to a body of knowledge and principles which has been developed to the stage where it can validly be described as an applied science. It is concerned primarily with the planning and direction of the overall organization on an individual farm to secure highest returns and lowest total costs consistent with maximum profits. It is therefore concerned with the constant process of making decisions.

Looking at the farm business as a whole, the farm management adviser attempts to provide profitable answers to the three basic problems of production:

- What shall be produced? — choice of enterprises.
- How much shall be produced?—size of enterprises.
- How can the resources available be optimally combined?

Besides these, there are problems of choice which have economic implications, when the farmer attempts to adjust to technical and economic change. For example, the economic principle that, for example, fertilizer should be added to a crop to the point where cost of additional output is just equal to the value of this output, is often forgotten, ignored, or just not recognised. Such principles are available to assist the farm management adviser in his approach to a farm problem.

The Role of the Farm Management Specialist

The primary purpose of agricultural extension is to provide advice on agricultural matters. But the adviser immediately becomes concerned with the farmer's basic motives for farming. These vary tremendously, and strongly influence the farmer's attitude to technical change and economic uncertainty, to obtaining credit, and risk-bearing. The introduction of a farm management approach therefore requires a change of purpose in Australian extension work, in the direction of helping the producer to identify and to achieve his economic and social objectives. This raises the question: To whom is the advisory officer primarily responsible — to the farmer he is advising or to the State which employs him?

The farm management specialist in an extension service has a threefold function — education, co-ordination, and application.

Education, or information, can be further subdivided:

1. To teach basic principles of farm management with the associated techniques of farm business appraisal and simple farm planning to all members of the extension department.

We are desperately short in Australia of trained farm management advisers; best use of our resources could be effected by using the few we have to give in-service training to our extension officers. It is absolutely vital that such courses are attended first by the senior men in the extension service, to produce encouragement from the top for this work. The trained farm management officers could also educate farmers themselves, although better returns for effort expended would result if they become advisers' advisers.

2. To provide basic economic information relating to incomes, expenses, and returns, and standards of efficiency, or advisory yardsticks, different types and sizes of properties in the major regions covered by the service. This is by far the more difficult role owing to the dearth of such information in Australia. What information is available should be made accessible through appropriate liaison between State and Federal departments, private consultants, industrial firms, and marketing organisations.

Co-ordination, or liaison, is the second main function of farm management in the extension service. For example, a pasture improvement plan re-

quires the combination of specialist knowledge on pasture establishment, pasture species, pests and diseases, and fertilizer responses. Integrating the scheme into an existing farm system requires further knowledge about stocking rates, animal-pasture relationships, problems of animal health and husbandry etc. All this technical knowledge requires final co-ordination into an economic context to achieve the ultimate objective — an improvement in farm income.

Interpretation and application is the third function of the farm management specialist who can discuss ideas with applied scientists who are planning new experiments. A closely associated task is to interpret results of research, demonstration plots, etc., into simple economic terms easily appreciated by advisory officers and farmers alike. Preparation of displays for local shows provides an ideal educational opportunity for farmer, advisory officer and economist. Development of basic blueprint plans for recommended practices for more common farm types is another way in which the economics officer can interpret new knowledge into terms understandable by the farmer.

Changes in attitudes needed

Before an effective contribution can be made by the farm management specialist, some changes in attitude are needed:

1. He is not simply another regional officer to solve ad hoc problems of farmers, although he should be available to guide and support district officers' answers to individual problems.

2. It must be recognised that extension officers, giving farm management advice, must be allowed to assist farmers to achieve their own personal objectives even though the State department has responsibilities for general policy and inspection work. It would be best if such responsibilities were removed from the functions of the extension service.

3. There must be recognition and agreement that extension is an equal partner with research. It is doubtful if extension would ever become competitive with research for operating funds, but better salaries and career opportunities in extension would attract and keep the qualified men it needs.

Whatever our speciality, we are all members of a team whose sole purpose is to raise the efficiency of our primary production. The farm management economist has no wish to usurp or interfere with the rightful functions of other sciences. He hopes only to be given encouragement and opportunity to practice his particular metier through a co-operative response to the challenge that faces us.

Private General Practice as a Consultant

By W. A. Beattie, Agricultural & Pastoral Consultant, Melbourne.

Of the specialised faculties, agriculture is the only one which has not established a private practising profession. Medicine, architecture, engineering, law and so on regard their private practitioners as the essential link with society and the economy.

Agriculture has not done so partly because it has in the past not been considered a learned enough profession. The old idea of farming for the fool of the family has stuck, and this is also reflected in the fact that farming has also no apprenticeship or other training scheme for its workers, though skilled trades as well as the other professions, all have. It was not considered a skilled occupation but one requiring traditional methods plus brawn.

The work of a professional man is to be in close contact with and to serve the public. His work is as much "people" as "agriculture." Thus he is brought into close contact with trustees, beneficiaries, rural credit and so on. Much of his work is of the continuing kind — a family adviser as it were, or an adviser to a company or Bank — and this work cannot be done by anyone else.

Extension officers of Departments of State cannot spare the time, are not completely free and independent and have not that personal link with producers which will enable them to do what they know they should be doing. It is not their fault. It is largely a restriction imposed by budgets and by politics.

In actual fact the gap is filled, but by a host of complete amateurs, a few good, most very bad. It is our duty as University men to take over the real responsibility and fill this gap with trained men, supplanting the amateur adviser. Talking to such advisers in Trustee Companies, Banks, Stock and Station companies and so on, one cannot but realise that on the one hand they do not understand the research worker and his job, they do not have any understanding of Government policy and they have not the training needed to give any other than extremely orthodox and often misapplied advice. We must take responsibility for this state of affairs if we continue to do nothing about it.

It is the role of a professional consultant to understand what the research workers are doing and to assist them by interpreting their work in the practical sphere, by feeding back to them the real problems

which they have to face, by requesting research in the vast uncovered field still existing, and to encourage wealthy private people to help endow research. It is their duty to understand and help to mould Governmental policy by stating facts which will be helpful to administrators and by offering constructive criticism. The producers' organisations do not do this because of their divisions, so that the Governments rarely get any lead. It is the main duty to serve the interests of clients by giving them good soundly based and thoughtful advice against their individual background, advice which will help the producer to make more money and to become more efficient and more prosperous.

One of the greatest difficulties is to have this profession established because farmers are suspicious, due to the very poor advice they have received from the amateurs and from the difficulty in getting advice from an overworked extension service. Also there is active opposition from the amateurs who fear displacement. But this must be fought in the public interest.

There is no reason for the present free service given to farmers by extension officers of Departments. A man who faces sickness in his family has to face some payments, for example by way of premiums to a Hospital Benefit Society in addition to his social service contribution, and often this does not cover everything. Sickness is a great misfortune with which everyone must be sympatheic. But if a man pays for this unhappy setback, why should his income be increased by an extension officer, and he contribute no part of the cost of advice? There is neither justice nor logic in this.

Adequate private professional advice should be paid for, just as is the case with every other profession. If we cannot increase farmers' incomes, then our work is not being properly done. It is very rare indeed not to be able to find some way in which a client cannot be made more prosperous.

Thus I believe that services should be paid for and that the Departments should be relieved from their responsibilities in this way and the money which they are granted in their budgets should be expended in the much more important field of applied research. One keeps on coming up against this huge problem of the lack of applied research.

At the moment the gap in application of research results is mainly caused by the lack of understanding of the amateur team of advisers operating in Banks, Trustee Companies, other companies and particularly Stock and Station Agencies, many of whom have great power over the operations of farmers through rural credit. They are in a position to dictate and do so. They have little in common with research workers and openly say so. Existing free extension services cannot operate to anything like an efficient extent. It is not the unwillingness of farmers to listen at all. It is the lack of interpretation and the misinterpretation and often the active opposition of amateur advisers which is at the root of the trouble. This is not stated sufficiently definitely when dealing with this most serious matter. I could cite very many instances.

I think therefore that the case for the profession is absolutely clear. But it needs two things. Probably legislation like that in Canada to protect it. Also an entrance qualification — possibly membership of the AIAS. Then finally it must have a code of ethics. Already I have been asked to do things which I do not consider to be consistent with the completely independent advice of a professional man.

Finally I think that the establishment of the profession would remove all the foolish misunderstandings between those who must form the complete pattern in the industry — fundamental research workers, applied research workers, officials with regulatory duties and policy making responsibilities, private professional practitioners, specialist practitioners who will find a large role, and the producer himself.

The Role of Farm Management Clubs

By Noel Douglass, Agronomist, Bombala Rural Advisory Service.

In four years of operation the Bombala Rural Advisory Service has raised production quite considerably for the 40 members, comprising 10 per cent. of landholders in the district. This has been done at no cost to the taxpayer and at considerable profit to the members. Rather unexpected supplementary effects have been that there has also been a significant increase in production on a further 70 per cent. of properties, and that although the Rural Advisory Service has engaged in bulk buying on behalf of its members, turnover of local business firms has also increased as a result of its activities.

This summarises the achievements to date of this, the pioneer farm management club in Australia.

The Bombala Rural Advisory Service has a constitution with very wide powers enabling it to do almost anything and to cover possible future expansion such as buying and selling land. It is governed by a board of management consisting of a chairman and six members who decide policy on such matters. Foundation members signed on for a three year term, to allow sufficient time for the

service to become established. In subsequent years, however, the members are free to join or leave on an annual basis. Initially, the fees were found to be disproportionate for the man with smaller acreage, so they have been adjusted to £30 per annum for the first 1000 acres and £15 per annum for each additional 500 acres. Somewhat over £3000 per annum income was provided to pay the salary of the agronomist and typist, provide travelling and office expenses.

After the end of the first year, during which the emphasis was placed on improvements in agronomy, real progress was limited by a lag in stock husbandry. It was necessary therefore to give more attention to standards of animal husbandry. In truth, this led the Service into bulk purchases of stock medicines and later into buying fodder, a business with a considerable turnover over four years. While this venture achieved the objectives of improving standards of husbandry, it entailed a lot of work requiring some diversion of normal advisory time.

Most significant development perhaps has been that members have become conscious of the benefits of long term planning. Farming in Australia has been held back by individualism and lack of planning. Any planning under 20 years should be reckoned short term—but when it comes to financing such plans a bank may consider twelve months a long term. So the farmer needs to borrow to finance short term profitable ventures which in truth will finance the long term plan. One farmer made a plan extending up to 1975 and included provision of a house for his son, now 12 years old, against the possibility of him marrying at age 26.

Another significant development has come from the introduction of new enterprises. For example, there appeared to be a need to provide bulls in the district. Members set out to produce bull calves; agents were circularised, giving them the facts, and it was found difficult to meet the demand so caused. One farmer made a considerable profit out of wheat growing, because of an unsatisfied demand on the South Coast for readily accessible grain. Another farmer lifted his production tremendously by using a fodder oat instead of a grain oat variety, which he had been using for 20 years without enquiring about the possibility of a more suitable variety.

To be effective, the Service must supply the needs of its members, from whatever direction the demand may come. Such Service could include a secretarial service for those who are members of local committees, entering into fund-raising for charities, settling disputes, determining the legal positions through channels, in fact, for doing any job demanded of the Service that affects the lives and livelihoods of its members.

A demand could arise from members for services not now being provided by private enterprise. The service most needed could be an accounting service provided by an accountant who would travel round to the farms and provide accounting and monthly cash balances. Legal fees are costly and savings could be made by such a club employing its own legal man. A bulk buying service could also be initiated.

Provision of such services would be made in competition with established businesses and professions and would be demanded by club members who formed a minority in the community. There is no fear therefore that the club movement will introduce a form of socialism.

It is unlikely that the farm management club movement will grow at such a rate that resignations of agronomists and others from the Department of Agriculture will become an embarrassment. But if an embarrassment were caused, this might result in an ideal form of chaos having the effect of pointing the need for increased numbers of trained men and improved salary rates and working conditions.

The job of the agronomist in a farm management club is that of an adviser and educator; if he tries to dictate to members he will become ineffective. The agronomist must resist the offers of salesmen pressing their particular brands; he needs a high code of ethics and must remain free of any business ties to remain effective as an adviser.

The agronomist of such a club is concerned with the problems of his individual members; the Department of Agriulture and other organisations are more concerned with wide-spread problems. But research men should not fear that there will not be a two-way flow bringing ideas for research back to them. The job of the agronomist depends on solving the problems of his customer.

The Co-operative Extension Service of the United States

By J. H. Boulware, Agricultural Attache, United States Embassy.

Agricultural extension in the United States is a Federal, State and County (roughly comparable to an Australian shire) co-operative system. The Service is relatively new, having been established by legislation in 1914. It grew rapidly and at all levels, from the

Federal Service in Washington to the Counties, currently employs about 14,000 workers. Of these 11,000 are at the local level and are in direct contact with the public.

The Co-operative Extension Service is one of the major agencies of the United States Department of Agriculture. It is the educational arm of the Department. None of its components is concerned directly with regulatory programs of any type. Its workers are expected to be in a position to inform farmers of the various control programs, but the Agency itself has no regulatory functions.

In each State and in Puerto Rico the Extension Service is a part of the State University system. It has no connection with the State Departments of Agriculture, which are purely regulatory and have no research or educational responsibilities. At the universities the Directors of Extension, Research and Resident Instruction report directly to the Dean of the College (Faculty) of Agriculture. The system is intended to provide the closest practicable co-ordination between workers in those fields.

Each State University employs extension specialists to the extent practicable in the fields it considers necessary to advise the County Agent. These specialists range in subject matter from the basic agricultural sciences, such as agronomy, agricultural engineering, irrigation and animal diseases, to youth (4-H) club leaders, home economists and public affairs. As a coincidence, it is interesting to note that eight of these public affairs specialists visited Australia in early 1960 to further their knowledge of foreign affairs in relation to agriculture. In numbers the specialists vary from three in the two smallest States to over 100 in California.

At the local level the County Agent and usually one or more assistants are the direct contact of the Extension Service with the public. There is, of course, a wide variation in the number of farmers in each worker's area, but on the average, each County Agent and an assistant has responsibility for about 750 farmers. This number is increased to about 1,000 when non-rural farm residents assisted are considered. In addition, about 4,000 women home demonstration agents and 600 4-H Club leaders are employed at the county level.

The County Agent works with farmers through voluntary local committees. These are considered an indispensable part of the organisation b ythe Extension Service. Methods of operation are not greatly diferent from those used by Australian workers in that the County Agents work through personal contacts, field days, meetings and farm demonstrations.

The work of the American Agent differs from his Australian counterpart in that he emphasises to a much greater extent economic and social aspects of farm life. In the early days of the service the emphasis was on production, but with the increased educational level of farmers, particularly on larger commercial farms, the problem of efficient production is much less critical than it was thirty years ago. I do not wish to imply that the problem of efficient production is fully solved, but the Extension Service has for a number of years tended toward increasd emphasis on other phases of rural life. Thus, in addition to work on productivity the County Agent and his assistant work on farm management and organisation; marketing, transportation, and utilization of farm products; conservation of natural resources; management of the farm and home; family living; youth development; leadership development; community improvement and public affairs.

Rapidly changing agriculture and the increase in part time farms and non-farm rural residents is presenting the Extension Service with new problems. The legislation establishing the service provides that it will serve the people of the United States — not farmers alone. The Service is actively planning adjustments to enable it to meet the needs of all people in rural areas.

The minimal educational requirement for a County Agent is a Bachelor of Science degree in some phase of agriculture. The current tendency is to insist that agents continue their education to secure a Master of Science degree and that specialists obtain a Doctor of Philosophy degree.

Financing of extension is also on a co-operative basis. The Federal Government provides about 50 per cent of the funds, the States 30 per cent and the Counties 20 per cent. This is an average and varies widely with the Federal portion ranging from 30 to 70 per cent.

Federal funds are distributed on the basis of population, need and of specific legislation. The tendency of local funds to fluctuate much more than the Federal portion is a drawback, but the sense of participation engendered by their use overrides this objection.

No picture of the American extension system would be complete without a brief mention of the excellent work done by the private specialist. Many outstanding men employed by the private agricultural advisory services, the purchasers of farm products, the transportation companies and companies supplying farmers with feed and fertilizer have been major factors in increasing the productivity of American farms. Many of these men are in fact former county agents or extension specialists who have been attracted by the higher pay normally available from industry

Book Review

Nutrition and Manuring of Tropical Crops

By Dr. A. Jacob and Dr. H. von Vexkull
Translated by Dr. C. L. Whittles

Verlagsgesellschaft für Ackerbau mbH, Hanover.

This book will find a place in the libraries of all whose work is associated with investigations of nutrition of tropical crops. In addition to the purely tropical species, some space is devoted to others like wheat, which though grown in the tropics to some extent, are not normally dealt with in a publication designed for use in the tropics. Their inclusion is fully justified but it is a little surprising to find a chapter devoted to Apples and Pears, and in which the information comes virtually exclusively from temperate climate countries.

The book, which is attractively produced, is well set out and yields information readily. It is divided into four parts:—

The first part deals with fundamental aspects of plant nutrition—not of course exhaustively, but nonetheless with some depth.

The second part will no doubt prove the most useful to investigators since it deals in considerable detail with the results of fertiliser investigations on each crop from the leading producer countries throughout the world. One would have liked to see much more Australian work examined but from the point of view of Australian workers this is not a major deficiency since we have ready access to our own literature. It is nonetheless surprising that Australian work on crops such as citrus, peanuts, pineapple and cotton finds very little mention; in some instances no reference whatsoever.

The third section is devoted to tables containing a wide variety of useful information in very accessible arrangement. It constitutes a handy reference for the laboratory worker on weights, measures and conversion factors; not new material, but conveniently presented.

Part IV is devoted to selected bibliography which would be of use to the student rather than the research worker.

Throughout the main section of the book the authors have given the bulk of the space to their summation of the work of others but their own observations are also given with commendable conciseness and clarity.

The book is a well worthwhile contribution to the subject it deals with and should appeal to a wide range of scientists, teachers, extension workers and students. The illustrations are notable for the fine reproduction and are fittingly placed in a book which takes into account the work of some 850 authors and publications backed by the authors' experience as obviously widely interested teachers.

W. A. T. SUMMERVILLE.

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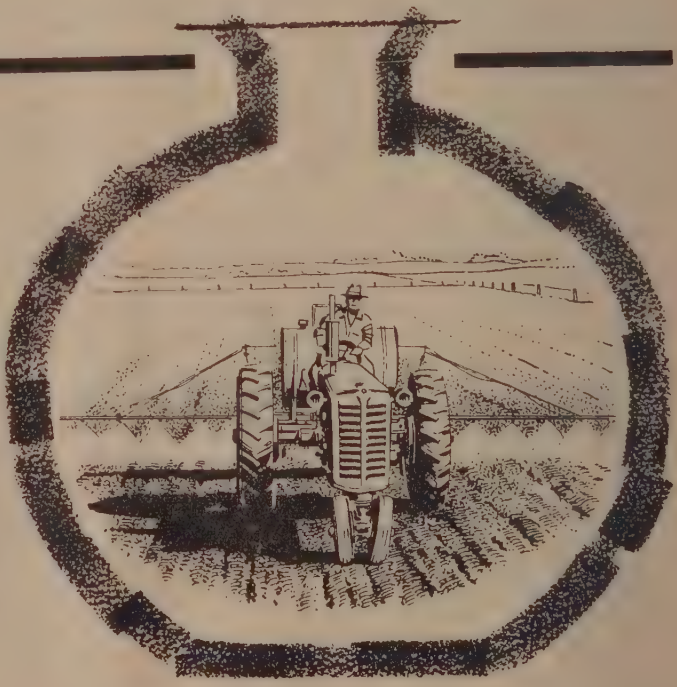

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SERVING INDUSTRY . . .
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News Items

Ecologists Unite

The Ecological Society of Australia was launched recently. This step represents the culmination of discussions among plant and animal ecologists over the past 18 months.

The objects of the Society are: (1) to promote the scientific study of plants and animals in relation to their environment and facilitate exchange of ideas among plant and animal ecologists; (2) to promote the application of ecological principles to the development, utilization and conservation of Australian natural resources; (3) to advise governmental and other agencies in matters where the application of ecological principles may be of assistance; (4) to foster the reservation of natural areas for scientific and recreational purposes and seek to ensure that such areas are soundly managed; and (5) to promote publication of the results of research in plant and animal ecology.

Management of the affairs of the Society is vested in a Council, whose members would ordinarily all be resident in one centre, although it is anticipated that that centre (and hence the office of the Society) may change from time to time. Members of the Council for the current financial year are:

President: *Dr. K. H. L. Key.*
Secretary: *Mr. J. H. Calaby.*
Treasurer: *Mr. A. G. McArthur.*
Other members: *Dr. D. P. Clark, Mr. L. R. Clark, Mr. R. M. Moore, Prof. L. D. Pryor.*

The Constitution provides for the Annual General Meeting to be held in the month of August. A general meeting will also be held in association with each meeting of A.N.Z.A.A.S., and it is at this that interstate contacts within the membership will principally occur. Additional meetings may be called at the discretion of the Council.

Apart from general meetings of the Society, it is anticipated that local groups of members will meet formally or informally from time to time.

A meeting will be held in association with the Brisbane A.N.Z.A.A.S. Congress, on Saturday, May 27, 1961. The meeting will take the form of a symposium on "Trends in Australian ecology", together with a business session and a social gathering.

The subscription for the current year has been set at one pound.

A New Publication

A new publication of interest to agricultural scientists throughout Australia is "Farm Policy", prepared by the agricultural economics group of the University of Western Australia, who describe it as an occasional bulletin on economic policies affecting Australian agriculture.

It is written mainly for farmers, but at a fairly high level.

Articles in the first edition are mainly concerned with the Australian dairying industry, but agriculture and population, and improvement of farm management are also discussed.

Although some articles have a West Australian slant, most are general both geographically and in subject matter.

New Director in W.A.

Western Australia's new Director of Agriculture is Dr. T. C. Dunne, who has been Deputy Director for several years.

Dr. Dunne graduated from the University of Western Australia, and started his career with the Department of Agriculture in 1926, as a wheat and sheep adviser. He later studied at the University of California.

From 1947 to 1956 Dr. Dunne was head of the Department's plant research branch and played a leading part in the research on economic development of light lands in Western Australia. He was closely associated with the successful programme of research of the now-famous Esperance region.

Dr. Dunne is a foundation member of the Institute and was President of the Western Australian Branch in 1947.

Visiting Professors

C.S.I.R.O. Division of Plant Industry has achieved the distinction of attracting a number of American Professors of world-wide repute to work at their Canberra Laboratories this year.

Dr. Arthur W. Galston, Professor of Plant Physiology at the Botany Department, Yale University, is spending 9 months at Canberra from July last. He has a Fulbright award and is doing research in plant physiology and biochemistry.

Associate Professor L. Bogarad of the Botany Department, University of Chicago, became the guest of Division of Plant Industry in June 1960 for a period of six months. He also has a Fulbright award and is working in plant biochemistry.

Dr. James Bonner of California Institute of Technology, Pasadena, spent two months in Australia from early October. During his stay he presented lectures and had discussions on phytotron research programmes.

SULPHATE OF AMMONIA

The consumption of nitrogen fertilisers in Australia is dominated by the sugar industry, which is by far the biggest user; more than half the nitrogen used in Australia is applied to sugar cane.

For application "straight" or mixed fertilisers, sulphate of ammonia has always been a popular choice in the sugar areas, because of its superior physical properties and its resistance to leaching in the humid tropical and sub-tropical climates where sugar is grown.

The bulk of the rest of the nitrogen is used on intensively cultivated crops, especially where irrigation is practised. Because of the importance of pasture legumes in Australian agriculture, an insignificant amount of nitrogen is used as yet on pastures and cereals.

Throughout the world, sulphate of ammonia is recognised as an excellent source of nitrogen for the production of mixed fertilisers. The Australian demand for these is increasing and so, too, is the proportion of nitrogen applied in combination with phosphorus and potassium. Ten years ago, about one-third of all the nitrogen used was applied in mixtures; today it is almost one half.

Australian fertiliser manufacturers make an extensive range of mixtures for all types of crops and soils and the development of this industry to its present efficiency assures ready availability of supplies at all times and at favourable prices.

NITROGEN FERTILISERS PTY. LTD., 500 BOURKE STREET, MELBOURNE, C.1.

SCIENTIFIC OFFICER

New Zealand Agriculture Department, Taieri

A Scientific Officer is required by the New Zealand Agriculture Department, Taieri. (Vacancy No. 3204).

Salary will be on the scientific officers scale up to £(NZ)1,700 p.a. dependent on qualifications and experience. Further promotion beyond this point would be on scientific merit.

Qualifications desired: Degree in science or agricultural science with zoology as major subject or other professional qualification where applicant has suitable biological training to equip him for work on eradication of noxious animals.

Duties: To apply existing knowledge to improvement of eradication methods for rabbits and wallabies. To devise new methods of eradication, if necessary. A house will be provided at reasonable rental.

Applications should be sent in the first instance to the New Zealand Government Senior Trade Commissioner, 14 Martin Place, Sydney, with whom applications close on 27th January, 1961.

The Australian Medal of Agricultural Science

Award for 1960 to Dr. D. O. Norris

The Australian Medal of Agricultural Science for 1960 has been awarded to Dr. D. O. Norris, in recognition of his outstanding contributions to plant virology and to the understanding of relationships and nutritional requirements of *Rhizobium* and tropical legumes.

Dr. Norris is a Senior Principal Research Officer of the C.S.I.R.O. Division of Tropical Pastures, Brisbane, and leads the group containing the sections of legume bacteriology, plant chemistry, plant nutrition and soil fertility. His own particular research interest is the host-*Rhizobium* symbiosis in tropical legumes and in this field he is now a recognised world authority. In an article entitled "Legumes and the *Rhizobium* symbiosis", published in 1956, Dr. Norris advanced the hypothesis that the legumes arose and flourished in the tropics and are still dominantly tropical. He considered that the cowpea type of *Rhizobium* associated with legumes is the ancestral and typical organism and this has led to a new approach in *Rhizobium* studies. Dr. Norris' studies have also shown quite clearly why tropical legumes have the ability to thrive in relatively poor acid soils, provided they are supplied with the right amounts of phosphate and minor elements. His work with the legume *Lotononis bainesii* resulted in the first record of a red strain of *Rhizobium* and also showed the very high degree of specificity that can occur in *Rhizobium* associated with tropical legumes.

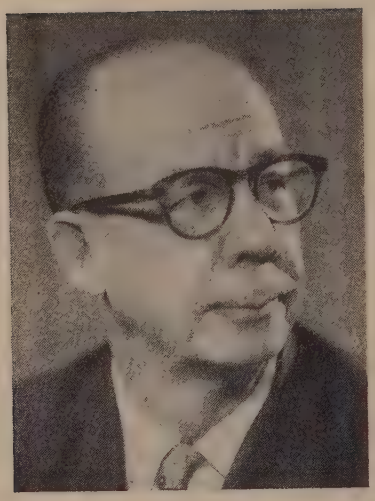
Dr. Norris has made and is making a major contribution to the pasture research of the Cunningham Laboratory as a proper understanding of the host-*Rhizobium* relationships has been a necessary pre-requisite to the development of legumes in pastures for the different zones in Queensland. A number of the previous failures in the establishment of legumes has been due to lack of the right *Rhizobium*.

Dr. Norris spent 15 years in the C.S.I.R.O. Division of Plant Industry in Canberra after his appointment in March 1938 as a tobacco pathologist. Most of this time he spent on plant virology and at the time he left Canberra was in charge of the pathology section. He was attracted by the scientific problems posed by the expanding research on tropical pastures in Queensland and was eventually appointed as legume bacteriologist to the then C.S.I.R.O. Plant and Soils Laboratory. Over the last seven years in Queensland Dr. Norris' pioneering urge has been more than satisfied and the results that he has obtained are vital to our understanding of tropical legumes.

Fellows of the Australian Institute of Agricultural Science 1960

The class of Fellows of the Australian Institute of Agricultural Science was created to honour members who have made an outstanding contribution to the profession, or to agriculture in general.

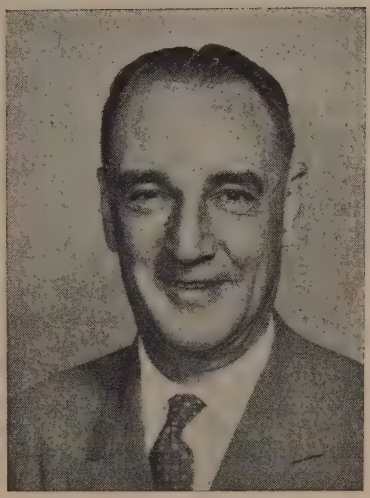
Dr. A. J. Anderson; Senior Principal Research Officer, Division of Plant Industry, C.S.I.R.O.



Mr. C. S. Christian; Member of the Executive C.S.I.R.O. and formerly Chief, Division of Land Research and Regional Survey.

Associate Professor G. W. Leeper; Associate Professor of Agricultural Chemistry, University of Melbourne.

Mr. H. A. Mullet; formerly Director of Agriculture, Victoria.



Mr. A. G. Strickland; Director of Agriculture, South Australia.

Professor W. L. Waterhouse; formerly Research Professor of Agriculture, University of Sydney.

Professor Sir Robert Watt; formerly Professor of Agriculture, University of Sydney.

Personal Notes

Australian Capital Territory

Dr. O. H. Frankel, President of the A.C.T. Branch, has been appointed by F.A.O. to the Research Sub-committee of the F.A.O. Freedom from Hunger Campaign Committee. He visited Rome in early October for meetings of the sub-committee.

Dr. S. M. Bromfield of C.S.I.R.O. Division of Plant Industry left in August for 12 months study at the Macauley Institute, Aberdeen. He is one of the few, if not the only, non-University person to be awarded the Royal Society and Nuffield Commonwealth Bursary. His subject is microbiologically induced chemical reactions, relating to the availability of phosphorus.

Mr. G. A. Stewart has been appointed Chief of C.S.I.R.O. Division of Land Research and Regional Survey, in succession to Mr. C. S. Christian who has been appointed a member of C.S.I.R.O. Executive.

Dr. R. A. Patterson has returned to the Bureau of Agricultural Economics with a Ph.D. in agricultural economics, newly acquired from University of Illinois.

Mr. K. D. Woodyer has transferred from C.S.I.R.O. Agricultural Research Liaison Section to Division of Land Research and Regional Survey. He will be concerned with administration of the Division's research stations at Katherine, Kimberley, etc.

New South Wales

Mr. F. Skaller who was Officer-in-Charge of the C.S.I.R.O. Poultry Research Centre at Werribee, Victoria, has resigned to become General Manager and Geneticist of Scientific Poultry Breeder's (A'asia) Pty. Ltd. at Kellyville near Sydney.

Mr. J. S. Thompson has joined the staff of the Agricultural Microbiology Department at the University of Sydney. He was previously stationed at the C.S.I.R.O. Regional Pastoral Laboratory at Armidale when he worked on nodulation of legumes.

Mr. S. W. Preston who was formerly Formulation Officer for agricultural products at Union Carbide (Timbrol), is now Technical Service and Applications Manager with the plastics division of the same firm.

Mr. H. V. Jenkins has returned to N.S.W. as Director of the N.W. Wheat Research Institute at Narrabri. He was formerly senior lecturer in agronomy at Adelaide.

Mr. A. J. Cowan formerly a Queensland member who was privately employed as a consultant in the Tully district, has become Northern Representative to the Shell Chemical Company in N.S.W.

Dr. S. L. Macindoe has recently occupied the newly created position of Chief Research Liaison Officer with the N.S.W. Department of Agriculture, where he was formerly Principal Agronomist. The new position carries the responsibility for research administration and publicity.

Dr. J. W. McGarity former lecturer in Soil Science at the Waite Institute, has transferred to the position of Senior Lecturer, Department of Agronomy, University of New England.

Victoria

Mr. R. G. Paddick, Plant Pathologist, Department of Agriculture, recently returned from a visit to the U.S.A. and U.K. His period abroad was spent studying the latest developments in the control of tobacco diseases. He spent extended periods in the major tobacco producing states of the U.S.A. and visited many research stations and Universities.

Mr. D. Kimpton, formerly Agricultural Extension Officer with the Department of Agriculture has taken a position with the administration section of C.S.I.R.O.

Mr. G. Arthur, formerly Sheep and Wool Advisory Officer with the Department of Agriculture has joined the Bureau of Agricultural Economics.

Mr. A. Buchanan, Milk Products Officer, Department of Agriculture recently returned from the U.S.A. where he gained the degree of M.Sc. at Iowa State University.

Mr. A. Doery, Manager, Ellinbank, Dairy Research Station recently visited New Zealand. He inspected a number of research centres and attended the Conference of the New Zealand Grassland Association.

Mr. J. Crook has joined the Department of Agriculture. He will be District Agricultural Officer stationed at Warrnambool.

Queensland

Queenslanders attending the Weed Control Conference held in Canberra from August 1-4, included *Dr. P. J. Skerman and Messrs S. L. Everist, V. J. Wagner,* and *J. E. Rawson.*

Mr. D. I. Sillar, Agrostologist of the Department of Agriculture and Stock left in September for two years leave of absence overseas. Mr. Sillar will visit the United Kingdom first and will then spend the remainder of the two years working in the dry pasture areas of the U.S.A.

Early in August the C.S.I.R.O. Queensland State Committee visited the wallum experiment station at Beerwah. *Mr. W. W. Bryan* has found that drainage here is unnecessary for the development of highly productive pastures; in fact drainage can be a disadvantage, especially during the dry part of the year. *Mr. C. S. Andrew's* research on the plant nutrient deficiencies of the area has made it possible for Mr. Bryan to develop productive pastures containing such species as *Paspalum plicatulum, P. dilatatum,* Pangola grass, *Lotononis bainessi, Desmodium uncinatum,* and white clover. One area is carrying 7½ sheep per acre throughout the year.

Dr. J. A. Morris of the C.S.I.R.O. Poultry Research Centre at Werribee, Vic., lectured the Queensland Genetics Society at the Cunningham Laboratory recently. He was among the southern visitors attending the Australian Animal Production Society's Conference in Brisbane.

Other visitors who have looked over the Cunningham Laboratory recently are *Mr. John Lee* from South Australia, *Dr. M. C. Franklin* of Sydney, *Mr. J. Kennedy* of "Belmont' and *Mr. John Goode* of the Kybybolite Research Centre, South Australia. Mr. Goode was interested in *Phaseolus tuberosa-arundinacea* crosses such as Ronpha grass, which would give a longer season of growth in the winter than ordinary *P. tuberosa.*

The mass spectrometer, a £9,000 gift from the Rockefeller Foundation of the U.S.A., has now been installed in the Cunningham Laboratory. *Dr. A. E. Martin* and *Dr. E. F. Henzell* will be using this for nitrogen isotope assays in connection with the movement of nitrogen between soil and pasture. In addition they will be able to study the fixation of nitrogen by the new pasture legumes being developed.

Mr. J. K. Taylor, Chief, C.S.I.R.O. Division of Soils, visited the Cunningham Laboratory in September after a tour of North Queensland areas with *Mr. G. D. Hubble* and *Mr. R. F. Isbell* of the Cunningham Laboratory. They examined soil problems, development and developmental potential in the brigalow lands of Queensland.

Professor T. K. Ewer gave a talk to the Cunningham Laboratory staff on September 30. The talk was entitled "An Animal Technologist Abroad" and in it Professor Ewer outlined his experiences with F.A.O. in Brazil and Burma.

Dr. David Goodchild and *Mr. N. E. Grylls,* virologists of C.S.I.R.O. Canberra, visited the Cunningham Laboratory with *Dr. J. T. Slykhuis,* an expert in cereal virology from Canada. They visited research workers at the Department of Agriculture and Stock and the Bureau of Sugar Experiment Stations, as well as making a tour of the Darling Downs cereal areas. Dr. Slykhuis found that the Darling Downs was almost free of serious cereal viruses, although he did find Barley Yellow Streak Mosaic in one isolated area. Virus-like symptoms were also found in some of the introduced grasses at the C.S.I.R.O. Pasture Research Station, Samford.

Professor L. J. H. Teakle, Professor Irvine Watson from Sydney, *Dr. L. G. Miles* and *Dr. E. M. Hutton* answered questions at the Queensland Graingrowers' Forum at Toowoomba on September 1. The Forum was part of the annual conference of the Queensland Graingrowers' Association.

Dr. O. H. Frankel, Chief, C.S.I.R.O. Division of Plant Industry, passed through Brisbane on his way to the Tobacco Research Institute at Mareeba. He spent some time at the Cunningham Laboratory looking into plant introduction matters.

Dr. E. M. Hutton visited the University of New England at Armidale in September and delivered lectures on pasture plant breeding to the final year Rural Science students. He also gave a lunchtime seminar to all those interested in agricultural science at the University.

South Australia

Dr. R. L. Specht, Senior Lecturer, Botany Department, University of Adelaide, has been appointed Reader in Ecology, Botany Department, University of Melbourne. He expects to take up this appointment early in 1961.

Mr. J. A. Beare, Soil Conservator, Department of Agriculture has returned after four months abroad. He visited the United States, United Kingdom, Italy and Israel where he studied recent developments in Soil Science.

Mr. P. M. Barrow, Department of Agriculture, has been recently appointed Senior Research Officer in Agronomy. He was formerly the Barley Agronomist.

Western Australia

Professor E. J. Underwood, Dr. A. J. Millington and Mr. G. H. Burvill have returned from overseas visits. All three attended the International Grasslands Congress at Reading, England.

Dr. M. Somers has returned from America, where he was doing research work at the Department of Animal Science at the Ohio Agricultural Experiment Station.

Mr. C. Spencer has left the Sheep and Wool branch of the Department of Agriculture to become a stock foods and nutrition officer with Westralian Farmers Co-operative Ltd.

Tasmania

Mr. L. R. Pyke has resigned from the Industrial Development Branch of the Premiers Department and transferred to Canberra where he has taken up a position with the Commonwealth Treasury.

Branch Notes

New South Wales

Two symposia were recently held in Sydney. In July, "Problems of the Horticultural Industries" were discussed; Messrs. Bruce French and Dick Spencer, both of the N.S.W. Department of Agriculture, dealt with the fruit and vegetable industry respectively; Mr. Peter Board, C.S.I.R.O. spoke on horticultural problems of the food processing industry. The September symposium dealt with "Insect Pests"; Messrs. Bruce Braithwaite and T. Bourke of the N.S.W. Department described their investigations into the clover root weevil and black soil scarab, and Dr. P. B. Carne of C.S.I.R.O. spoke on biological control. These meetings were each attended by 20 to 30 members and visitors.

A most successful full-day symposium on "The Agricultural Development of New England and North-West N.S.W.", was held in August by the Northern Sub-branch, in conjunction with the University of New England. Amongst the 150 who attended were many graziers. A total of 18 papers were presented.

In August, also, the N.S.W. Branch in conjunction with the Agricultural Engineering Society was addressed by Mr. H. Fail, head of the Department of Agricultural Engineering, University of Durham. His subject was "Experiences in Education and Extension Work in Agricultural Engineering". About 50 people were present but the Institute was very poorly represented. Mr. Fail showed some excellent colour slides depicting recent developments in rotory hoe and tractor designs which stimulated much discussion.

A symposium on soil and plant analysis for the determination of fertilizer requirements has also been arranged. This subject was stimulated by anxiety at the activities of certain people in this field.

The Branch has taken part in the Jubilee activities associated with the 50th Anniversary of the Agricultural Faculty of Sydney and the 25th Anniversary of the Institute. A scholarship fund aimed at raising £2,500 has been half subscribed although only 60 graduates have contributed. A chicken barbecue was very successful and a joint Institute and Faculty dinner was held in October. Sir William McKell was amongst the speakers.

The N.S.W. Branch Committee has decided to set up a permanent secretariat at the Agriculture Club in the new Agriculture House, Macquarie Street, Sydney. General administration costs will be substantially reduced and difficulties associated with administration by part-time honorary officers will largely be resolved. The Branch will be able to reserve a licensed club room and dining room, and a lecture theatre for its activities. Members will be eligible to join the club and the Branch will have a permanent address listed in the telephone directory.

Victoria

At a meeting on July 22, Mrs. Edith Cooper spoke on her recent visit to Russia, a graduate of the University of Western Australia, she is a well known sheep breeder at Tatyoon, Victoria. While in Russia she spent some time on a State Sheep Farm and also at the Central Ukraine Cattle Research Station.

The Annual Dinner was held on September 27 at the Union House, University of Melbourne. A large gathering of members and friends enjoyed a buffet meal followed by a cheese tasting.

The guest speaker was the Vice Chancellor of Monash University, Dr. Mathieson. In his own inimitable style he told of a typical working day in his life at the present time.

Until a few months ago the campus consisted of one solitary house. His time at present is largely occupied with co-ordinating the efforts of many people to enable some buildings to be ready for the next academic year.

Western Victoria Sub-Branch

At a meeting held in Hamilton, Victoria, on October 14, it was unanimously agreed that a Western Victorian sub-branch be formed. There is a potential of 40-50 members in the area concerned ranging from Colac to Kybylolite in South Australia.

The meeting was addressed by Victorian President, Mr. Harold Dickinson and also the Executive Officer, Mr. J. A. Roberts.

A Committee of five was elected to conduct the affairs of the branch.

Chairman: *Mr. H. Bishop*

Vice Chairmen: *Mr. J. P. Makeham* (Colac)
Mr. L. G. Heath (Horsham)
Mr. P. Geytenbeek (Kybylolite)

Secretary/Treasurer: *Mr. A. K. Stubbs*

It is felt that the formation of this sub-branch will be of benefit to members in the area who are frequently prevented from attending Melbourne meetings because of the distance involved. It is planned to invite non-members to some meetings and it is hoped that a close liaison between the Institute and farmers will result.

Queensland

The August ordinary general meeting was held at the C.S.I.R.O. Cunningham Laboratory, St. Lucia on August 24. The main business of the evening took the form of a discussion on various aspects of "Aircraft in Agriculture".

Mr. S. Everist, Government Botanist spoke on "Aircraft for Agriculture" describing types of aircraft, the task required of them, their advantages and their limitations.

Mr. A. Arvier of I.C.I.A.N.Z. discussed "Aircraft with Agriculture" highlighting the practical value of aircraft as extra tools for the farmer.

Mr. J. Wolfe, Extension Training and Research Officer of the Department of Agriculture and Stock discussed "Aircraft for Extension Work and Station Use in Pastoral Areas".

The Annual Public Meeting organised by the Branch was held on September 13 at Shell House. As in past years representatives of organisations concerned in agricultural and allied fields were invited to hear selected speakers and meet members of the Branch. Two papers were presented:

Mr. R. Moore—Hybrid Grain Sorghum in Queensland.

Dr. G. I. Alexander—Trends in beef cattle breeding in Queensland.

On Saturday, October 1, a trip was arranged to inspect various aspects of agriculture on the Darling Downs. Local members gave short addresses and conducted visiting members around the numerous field trials in progress.

South Australia

At a Branch Meeting, held on September 20, Mr. Herbert Fail, Head of the Department of Agricultural Engineering, University of Durham, gave an address on "Progress in Farm Mechanisation in Britain".

Following the success of its 1959 Seminar at Roseworthy College, the South Australian Branch organised a similar function again this year.

Entitled "The Farmer and the Future", it was an all-day function held at Burnside Town Hall on Thursday, September 29. By using a larger hall it was possible to invite farmers as well as members of industry catering for agriculture. Almost two hundred came to hear the six addresses and join in the sherry party afterwards. A buffet luncheon, and morning and afternoon tea were provided.

The S.A. Branch brought Professor K. O. Campbell from Sydney University to give the leading address. He was supported by a strong team of speakers who covered the various aspects of the farmer's problems in the future.

The Branch records its gratitude to the speakers who made the day the success which it was. Mr. T. C. Miller, Chief Horticulturist, Department of Agriculture, was the Seminar Convenor.

The Programme:—The Farmer and the Future.
Mr. J. C. M. Fornachon, South Australian President for 1960.—Introductions.
Professor K. O. Campbell, Professor Agricultural Economics, University of Sydney.—The Economic Position of Australian Agriculture.
Mr. W. F. Nankivell, Member for Albert in the South Australian House of Assembly.—The Farmer Views the Future.
Mr. M. R. Irving, Chief, Division of Animal Industry, Department of Agriculture, South Australia.—Animals in Australia's Agriculture.
Dr. J. Melville, Director, Waite Research Institute, University of Adelaide.—Where Research is leading Australian Agriculture.
Mr. H. W. Ehmcke, Manager of Robby's Aircraft Ltd.—Agriculture and Aviation.
Mr. R. I. Herriot, Deputy Director of Agriculture and Chief of Division of Extension Services and Information, Department of Agriculture, South Australia.—The Extension of Agricultural Knowledge in the Future.

Tasmania

The combined meeting of the Tasmanian Branches of the A.I.A.S. and the R.A.C.I. on July 14 heard the Chief Entomologist of the Tasmanian Department of Agriculture speak on "Insect Resistance to Insecticides and its Economic Significance". Mr. Miller dealt with the many ecological and physiological aspects of this problem illustrating with examples drawn from a wide range of occurrences both locally and overseas.

A general meeting of the Branch held on September 13 was addressed by Mr. H. Fail, acting-Professor of Agricultural Engineering at the University of Durham. Mr. Fail spoke on "Progress in British Farm Mechanisation", concentrating mainly on recent developments in weed control but dealing also with recent advances and researches in harvesting and other machinery.

At a general meeting held on October 6, the Executive Officer, Mr. J. A. Roberts, gave a review of the Institute's finances and answered members' queries. A move to alter the Branch By-laws to provide for the election of a President-Elect to the Committee was deferred.

Mr. D. Berry has been appointed Vice-President of the Branch to replace Mr. S. M. Sykes who became President following the resignation of Mr. J. R. Ward from that position.

Western Australia

Guest of honour at the W.A. Branch annual dinner on Friday, October 14, was Federal President Mr. A. L. Tisdall, who visited this state early in October.

During his visit Mr. Tisdall toured irrigation areas in the south-west of the state, and addressed a public meeting at Waterloo, about 100 miles south of Perth. The meeting, organised by the Institute, was well attended by irrigation farmers from surrounding districts, and proved again the success of the branch policy of holding one of two public meetings a year in country areas.

Another special guest at the dinner was Mr. G. K. Baron Hay, who retired in Auguest, after nearly 20 years as Director of Agriculture. A presentation was made to Mr. Baron Hay in appreciation of his many years of service to agricultural science in Western Australia.

A general meeting on November 25 discussed the agricultural potential of the sandplain country near the coast and 100 and more miles north of Perth. Part of this country has been taken up for soldier settlement, and another section has been put forward as a suitable site for a State-sponsored civilian settlement scheme.

Over the past few months the Branch has co-operated in the formation of a West Australian Branch of the Agricultural Economics Society. A number of members have joined the society, whose inaugural meeting was held in conjunction with an Institute meeting. The Agricultural Economics Society Branch has since held a number of well-attended and interesting meetings, the last of these being a discussion of the scope for improving the present wool marketing system.

The Agricultural Economics Society is open to any persons interested in the economic problems of agriculture, and as such holds interest for many local Institute members.

Farmers' and Scientists' Joint Conference: The Branch has agreed to hold the 1961 conference on February 14-16. Its theme will probably be: Increasing the efficiency of livestock production through better methods of animal husbandry and pasture management.

Australian Institute of Agricultural Science

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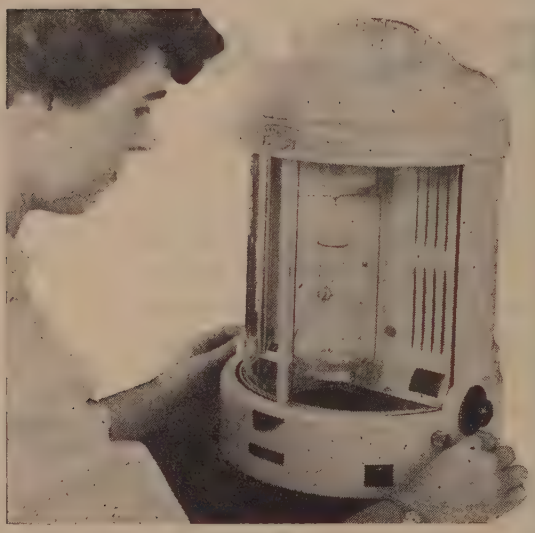

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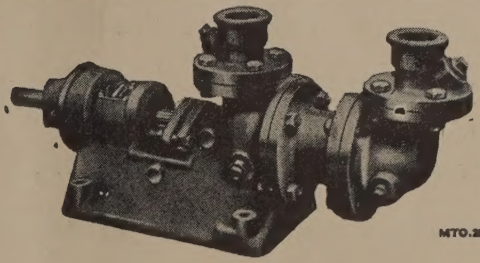

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DIPS FOR CONTROL OF LICE AND KEDS

"DOUBLE ACTION" Powder Dip containing Arsenic and Rotenone.

"PARADIP". A liquid arsenic rotenone dip ready to use.

"GAMALENE" Liquid B.H.C. Dip.

FOR ITCHMITE, LICE AND KEDS

"Rotalene" Liquid Rotenone B.H.C. Dip.

FOR CONTROL OF KEDS, LICE AND BLOWFLIES

"Aldrene" Liquid Dip. Contains Aldrin. Highly concentrated.

Obtainable from your Local Agent, Wool House, or

DRENCHES

"Liquaphene" Liquid Phenothiazine Drench. No mixing, free-flowing, non-settling. Controls parasitic worms and reduces pasture reinfestation.

"Microphene" Microfine* Phenothiazine Powder. Micronised to conform with latest research findings on particle size and purity.

FLY STRIKE CONTROLS

"Aljet". A highly concentrated liquid containing Aldrin. For lasting protection.

"Dieljet". Contains Dieldrin. Absorbed into wool to give prolonged protection.

"Diazajet". Contains 51.2% Diazinon—for long term protection.

* Registered Trade Mark. Indicates a true micronised product.

COMMONWEALTH Fertilisers and Chemicals Ltd.

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